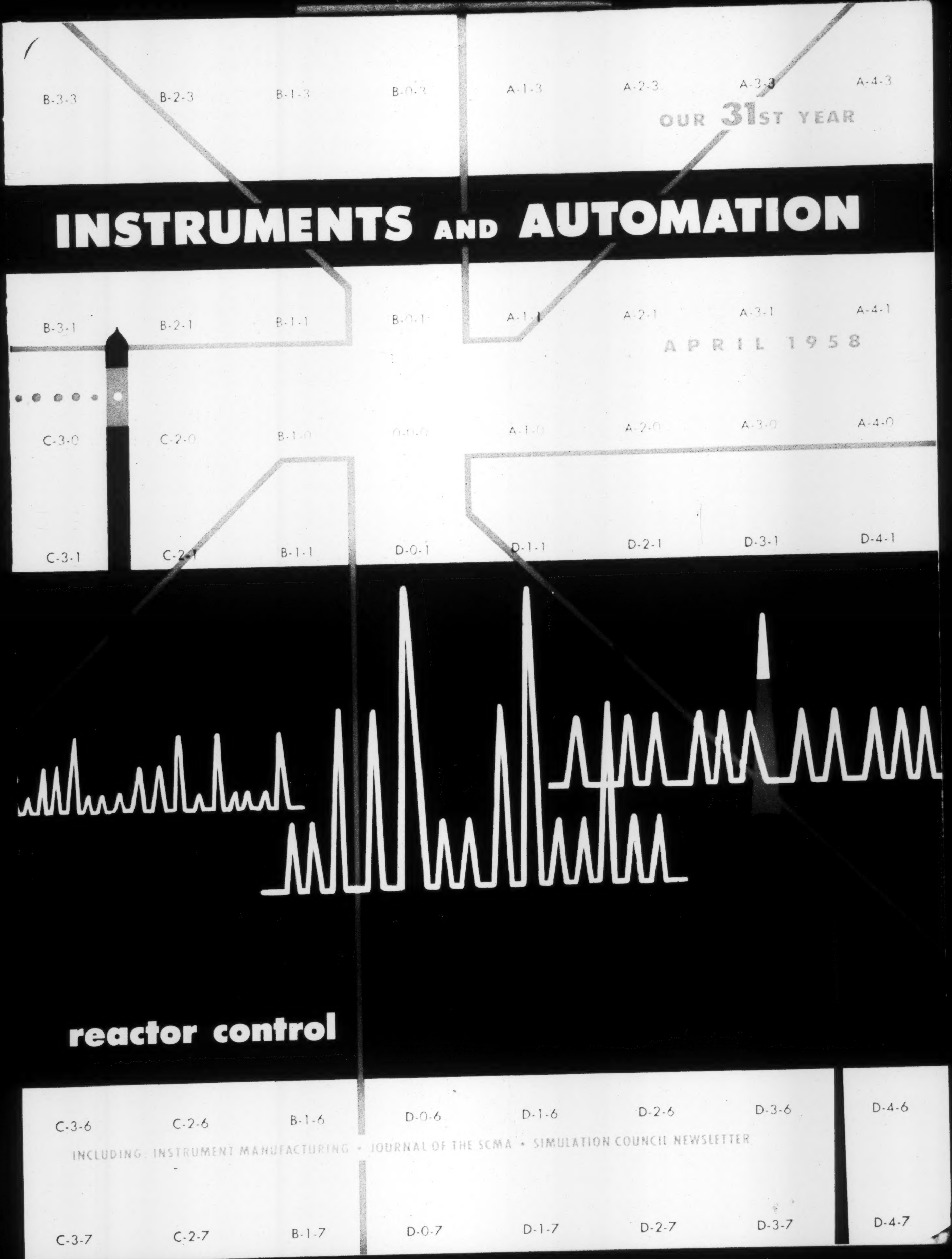
OUR 31ST YEAR

INSTRUMENTS AND AUTOMATION

APRIL 1958

reactor control

INCLUDING: INSTRUMENT MANUFACTURING • JOURNAL OF THE SCMA • SIMULATION COUNCIL NEWSLETTER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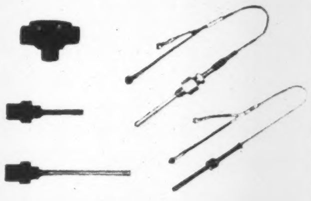

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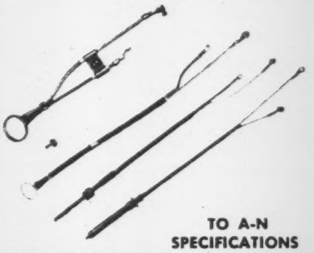

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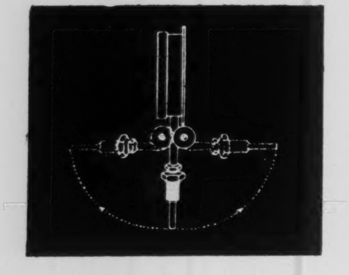

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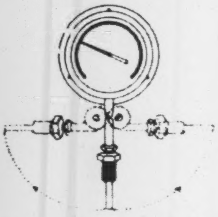

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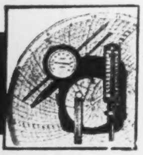

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APRIL 1958

NO. 4
VOLUME
31

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THE MAGAZINE OF INSTRUMENTATION AND AUTOMATIC CONTROL SINCE JANUARY 1928

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AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

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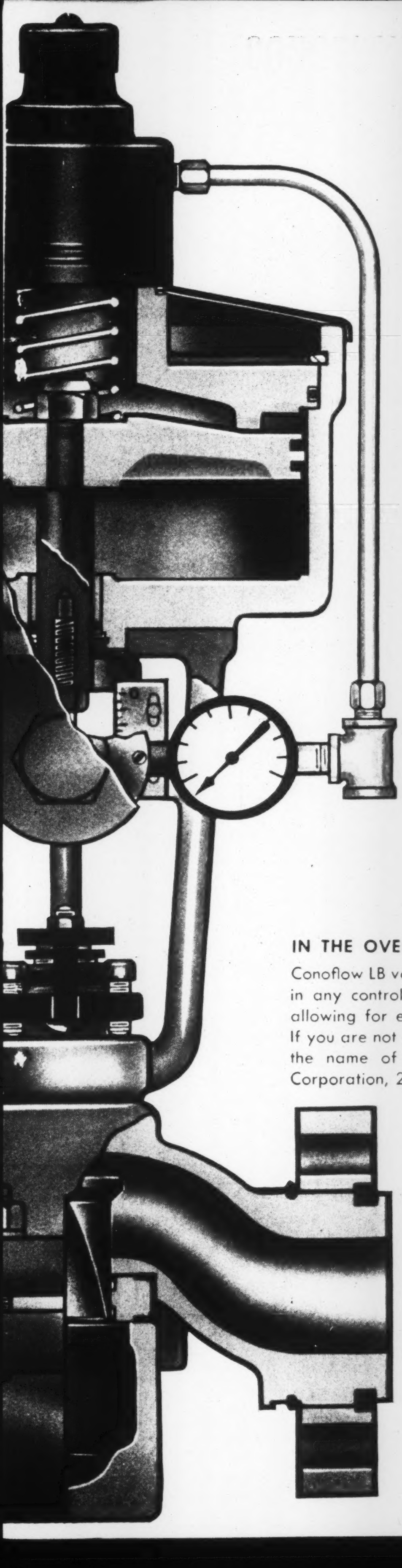

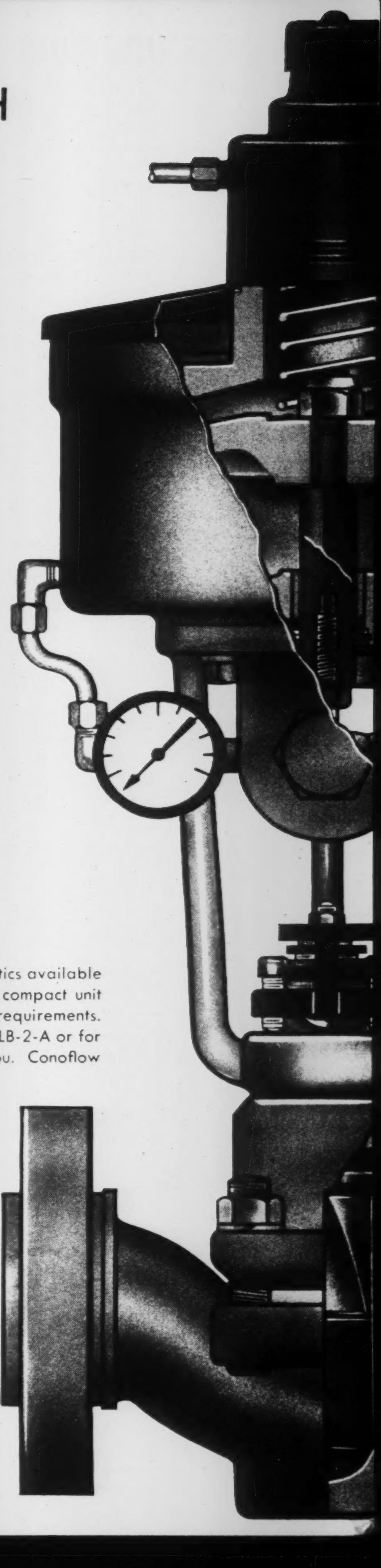

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For more information circle **6** on inquiry card.

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For more information circle 7 on inquiry card.

to the editor

Editor, I& A:

Referring to your January issue of *Instruments and Automation*, you point out some very essential facts, and the whole problem of systems engineering and your comments certainly justify the serious consideration of everybody in this field.

Eugene Mittelmann
Consultant
Chicago, Ill.

Editor, I& A:

We all enjoyed tremendously your survey of systems vs. hardware which appeared in a current issue. If this has become the philosophy of your house, as we believe it has from the lead editorial, we must also pass along many compliments with great hopes for the future.

We would like to make much of this among our clients and would appreciate it if you could send us copies of the entire issue.

Walter L. Werbos
Vice President
Harry P. Bridge Co.
Phila., Pa.

Editor, I& A:

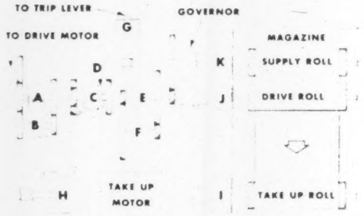
Your entire January issue is notable for its realistic approach to the problem of "Systems or Hardware?" in pointing out the dangers as well as the advantages of "the systems approach." Your issue is of great value to our industry. Economists examining this industry have pointed out that it is not highly or even sufficiently profitable because too much service is given away in selling the product. As your editorial points out, this is a matter of concern to the customers as well as to the suppliers.

The suggestion in your editorial, of a Systems Engineering Council for the mutual protection of the "hardware" manufacturer and the systems engineer, is a worthy one if it can be made to work. Perhaps it could be if only there were an easily defined distinction between the application engineering logically provided by the manufacturer and the systems engineering logically provided by the paid consultant. As I read it, your magazine attempts to discriminate between the two on the basis that the application engineer

electric motion control facts FOR IDEA MEN

Touch-a-button speed changes through electric clutch-couplings

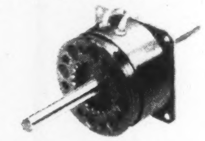
Ten Warner electric clutch-couplings are "automatic power links" in this precision instrument for measuring and recording high-frequency phenomena. In the power transmission (below) they control recording speeds. In the magazine they control rate of flow of photosensitive paper. Functioning by electromagnetic attraction of armature and field, the transmission clutch-couplings permit remote selection of recording speeds from 5 to 400 ipm without stopping to shift gears.



Three pairs of clutch-couplings (A to F) are used in the transmission gear train. Use of clutches A and B provides 2:1 reduction; C and D, 4:1 reduction; E and F, 16:1 reduction. Clutch G, coupled to the main drive through a gear set, controls length of paper to be run for recording. Clutch H couples the main drive to the rewind shaft when a high recording rate requires faster acceleration of take-up roll rotation than possible with the small rewind motor alone. Clutch-couplings I and J couple main drive and take-up shafts to their respective rolls. Brake K stops the supply roll and keeps it from unwinding when machine power is cut off by the governor.

Use of Warner electric clutch-couplings simplifies removal of the magazine for darkroom processing of recording paper. All the operator has to do is de-energize the field, unlock the magazine case, and slide the armatures away from the fields and rotors.

Warner Stationary-Field Electric Clutches



Split-second operation and precise control for automatic cycling, indexing, positioning, or tension control are design advances you can give your customers with Warner electric clutches and clutch-couplings. Capacities up to 100 hp.

Send for more IDEAS: Warner will send you application sheets showing how machines in your industry were made more profitable, easier to control, simpler to maintain.

WARNER ELECTRIC BRAKES AND CLUTCHES

Warner Electric Brake & Clutch Co., Dept. IA-4
Beloit, Wisconsin

For more information circle 8 on inquiry card.

largely confines his endeavors to applying his company's standard products and that his effort is limited by the value of the products involved. Unquestionably, this is the way it should be. Unfortunately, I don't think this is the way it really is.

Having had some experience as an application engineer, I can assure you he generally is less concerned with using the standard products of his company than he is in satisfying the needs of his customer. Ask the Production Manager of any instrument company; he will tell you that no self-respecting application engineer will use a standard unit when he can substitute a special. It's more fun that way.

Nor does the application engineer stop when the cost of his time equals the normal profit on the "hardware" involved. The sales engineer has told him that if this first installation works out, he can sell 10 more in his own territory and could sell 200 more if he only had Joe Smith's territory. Such potential justifies spending time all out of proportion to the value of the equipment. (Unfortunately, the process becomes obsolete before the problems are worked out, so the potential has disappeared because the application engineer took too much time.)

Where, then, should the work of the application engineer leave off and the work of the systems engineer begin? True, the systems engineer has more time and talent to expend. That is his stock in trade, for which he is (or should be) paid. True, the systems engineer is at liberty either to redesign the instrument system or the plant in order to optimize the process. However, the application engineer has equal freedom within the limits of his talents and the policy (or lack of policy) of his company. In other words, between the blue of pure application engineering and the yellow of pure systems engineering, there is a huge area of green and the green always looks grassier on the other fellow's side of the fence.

The problem is that our industry does not sell "hardware." We sell a highly technical product one that requires much engineering time and talent both in designing it to suit the users' general requirements and in applying or adapting it to meet his specified needs. The object is to do the very best job of meeting these requirements and needs (to satisfy the customer), or to surpass them (to outdistance competition). The job of satisfying customers and outdistancing competition is basic with us sales people: at what point should

Continued on page 568

Something Special

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For those jobs, only a manometer can do . . .

When you're faced with precision calibration, production checks of other accurate instruments, or any kind of laboratory pressure work . . . in fact, any time you need better than 0.1% accuracy that's the time to add a W&T precision mercurial manometer.

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range: 0 to 31.50 inches Hg., or any other desired pressure unit of equivalent range.

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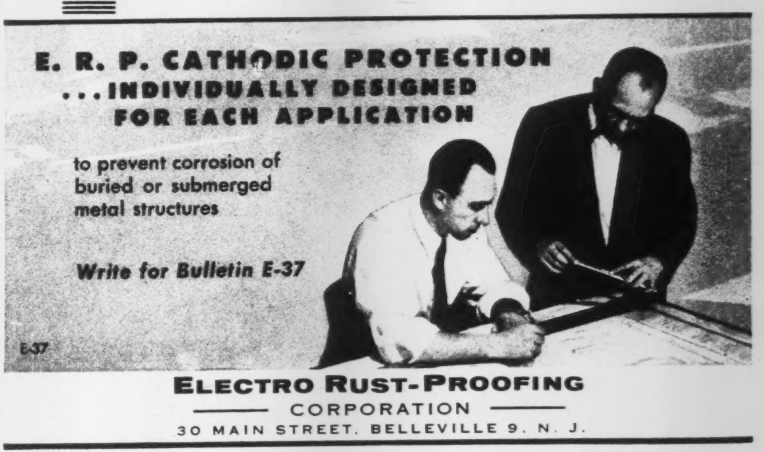
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to prevent corrosion of buried or submerged metal structures

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E-37

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For more information on: Manometers circle 9 on inquiry card; Cathodic Protection circle 137.

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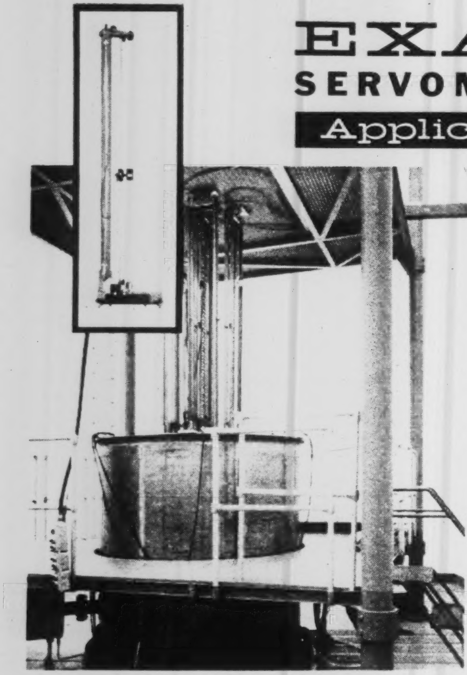
SERVOMANOMETER*
Application Notes



Servomanometer at Vallecitos Atomic Laboratory

An Exactel Servomanometer (inset) at the General Electric Vallecitos Atomic Laboratory is used for precise measurement of the height of the water which controls the reactivity of the Dresden Critical Assembly Reactor.

The tube of the Servomanometer is connected to the tank so that the same water level exists in the manometer tube. The instrument operates adjacent to the reactor and transmits the level to the control room.

Exactel Bulletin 500 sent on request — Describes Servomanometer use and theory, together with specifications on 38 standard models in ranges of 32-120 inches.

Exactel Instrument Company
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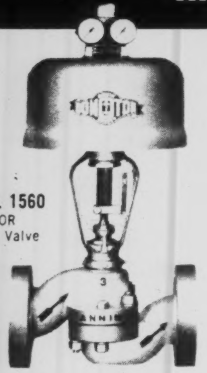
Los Altos, California

**Trade name of the Exactel Instrument Company*

PRECISION OF A MANOMETER — UTILITY OF A SERVO

For more information circle **10** on inquiry card.

DOMOTOR DOES MORE IN THE ACCURATE, AUTOMATIC *CONTROL* OF HARD-TO-HANDLE FLUIDS



MODEL 1560
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Is your problem the precise control of erosive and corrosive fluids at high or low temperatures?

If so, investigate the ANNIN DOMOTOR control valve, wherein internally controlled differential pressures, acting across a sealed-in piston, provide the motive power for operation. The DOMOTOR combines powerful valve action with exceptional stability, greater plug travel and guaranteed positioning accuracy of 1 1000 of valve travel.

Standard models withstand pressures to 5,000 psi with special applications to 50,000 psi. Effective temperatures from −425°F to 1600°F.

Other models by Annin —
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Handwheel Valve, Figure 15

ANNIN

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Control VALVES

For more information circle **11** on inquiry card.

LETTERS —CONTINUED

we turn the job over to the systems engineer? You will say this should be done at the point where the job begins to yield a loss instead of a profit. But is this point predictable or even discernible?

There is, of course, a tremendous need for the systems engineer in today's highly complicated technology. He is a consultant and should be paid adequately for services rendered just as consultants are paid in any other field. It is a misfortune of our industry that, as your editorial points out, many systems engineers must resort to manufacture in order to make a livelihood. What's wrong? The trouble is that instruments are too complicated and don't cost enough. It just doesn't seem right to pay a systems engineer ten thousand dollars to recommend a five thousand dollar control system. Few users yet appreciate that the added ten thousand dollars may make the difference between profit and loss for his one hundred thousand dollar plant. It would be different if we were in the business of selling the one hundred thousand dollar plant then the ten thousand dollars additional wouldn't look so large. Perhaps because of their fundamentally low cost, the real value of instruments is not yet appreciated.

Of course, there is much more to be said about the situation and its causes. I, for one, certainly do not know the answers. Anything you can promote or do to further the ideas so ably presented in your January issue will certainly be appreciated by all. The users, will of course, gain most. They have great opportunities for improvement of their processes by the new ideas and new instruments (not the least of which are electronic controls) that are available to them should they choose to investigate these services on a realistic basis.

Karl W. Peterson
Sales Manager
Manning Maxwell & Moore, Inc
Danbury, Conn.

Editor, I&A:

Your January 1958 *I&A* editorial "Systems or Hardware" sure calls out what is holding back system development in the process industries. Namely:

1. To sell their wares, component manufacturers dabble in systems, which so far has brought them mainly red ink.
2. Systems men, for bread-and-butter, try their hand at component

sales. Usually a wrong move for novice product pushers.

3. The poor customer doesn't know what to do, because systems men sell stuff, and hardware merchants claim to set up systems too. So he either buys a proprietary package, or just plain doesn't buy.

Every one takes a beating and the state of systems art suffers, because there is no policy as to who makes, who plans, and who uses.

Over-simplified, the materials men should stick to manufacturing their line, and applications engineering. The systems men (either on the user's payroll or free-lance consultants) would pick the best components and systems to do the job. They would have no ties with vendors. The customer should demand that components not carry built-in engineering costs, for he should know enough to rely on "pure" systems men for system design.

"Free engineering" is the kernel of what causes the trouble — depending on the hardware vendor for system design leads to a patent medicine system rather than a prescription system. Free air and windshield wiping is okay for a gas station. But how can systems engineering be "free" when it can cost much more than the worth of the parts?

Other professions have proved that the man who sells a "thing" must not be he who specifies when and where it is to be used. What would you think of a pharmacist who wraps free medical diagnosis with his pills? Or an oldtime quack M.D. who peddles his pet elixir? Not until the apothecary and physician each assumed their separate roles of compounder and adviser, respectively, did the two professions achieve high status, and the patient cured rather than killed. The analogy is obvious.

It has been proved by architects and engineers allied with the construction industry that a professional unbiased middle-man is needed, to match the impedance between the supplier and user of materials. No longer do boiler manufacturers plan heating systems, or the electrical contractors plan the wiring. The building customer now knows enough to separate materials from "system" design, and depends on his impartial architect and consulting engineers. The builder wouldn't go for a lumber yard that tried to price plans along with planks. This is more than can be said about some systems customers, who look for the easy way, and seem to want a package deal as well as a packaged system.

It is our experience that the fabricating industries, for whom we are automation system consultants, are

Continued on page 571

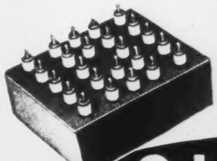
RESISTANCE NETWORKS

Maintain Precise Voltage/Current Ratios

In missiles, computers, instruments . . . in ac or dc circuits . . . wherever voltage or current must be adjusted within close limits . . . Shallcross Networks provide accuracy and dependability.

FROM A RELIABILITY STANDPOINT, use of sealed networks is recommended in preference to individual resistors to eliminate harmful preventive maintenance. In field servicing the technician is often not aware of the precise T.C. and reactance matching of otherwise seemingly ordinary MIL resistors. In addition to special winding techniques the individual resistors in critical networks are usually stabilized. Replacement of any resistor with a standard MIL type could cause equipment malfunction, and must be prevented.

FROM A DESIGN STANDPOINT Shallcross' skill and ability assure adherence to the most exacting temperature, stability, shock, size, and weight requirements. Shallcross precision engineered networks have proven effective both in ground-based and airborne equipment.
Two typical Shallcross resistance networks are described below. Many others with specialized electrical and mechanical characteristics are regularly manufactured.



SECONDARY-STANDARD VOLTAGE REFERENCE SOURCE is built around this 24 terminal Shallcross resistance network. Using an oil-filled enclosed network of 21 matched T.C. resistors with stabilities of 0.001%, the instrument maintains an **absolute** accuracy of 0.01% from 0° to 50°C.

Shallcross

GROUND-SUPPORT COMPUTERS employ a number of these hermetically-sealed, standard, octal, plug-in networks. Networks have up to 10 specially wound resistors which are critically located and lead-dressed to meet specifications at 400 cycles. All units are production tested for voltage division accuracy and quadrature error using a precise 400 cycle bridge.

SHALLCROSS MANUFACTURING COMPANY • 510 Pusey Ave., Collingdale, Pa.

For more information circle 12 on inquiry card.

IMPERIAL HI-SEAL BUTT-JOINT FITTINGS

now available in brass, steel and stainless steel

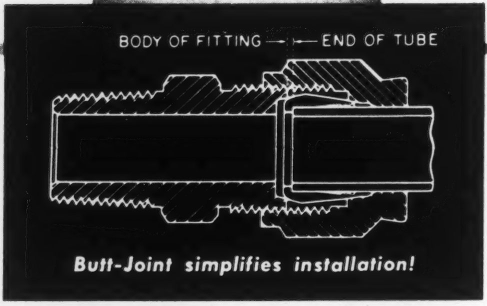
HI-SEAL

the most important advance in tube fittings in 20 years

- No flaring or threading
- Withstands higher pressures
- No need to spring tubing
- Permits closer tube bends
- Fast, foolproof assembly
- Meets J.I.C. and A.S.M.E. standards . . . Listed by UL

Tremendous popularity of steel and stainless steel Hi-Seal fittings has led many users to request Hi-Seal fittings in brass. You wanted them—Imperial made them — new brass Hi-Seal fittings . . . plus steel and stainless steel fittings so you can profit from famous Hi-Seal advantages . . . like butt-joint, close bends, quick assembly in the metal best suited to each application.

Tube doesn't enter the body of the fitting. It bottoms on shoulder of the sleeve. Camming action of the nut causes sleeve to form a collet-type triple-seal grip on the tubing.



Butt-Joint simplifies installation!

Final circumferential seal is made by tapered edge of sleeve. No tube torqueing when making a joint. Can be disconnected and reconnected as often as desired.

HI-SEAL
IMPERIAL

Write for Bulletin 3061 and complete facts.

See Your Imperial Distributor

IMPERIAL **THE IMPERIAL BRASS MFG. CO.**

6300 W. Howard St. • Chicago 31, Ill. • *In Canada:* 18 Hook Ave. • Toronto Ont. • Dept. IA-48

For more information on Fittings circle **13** on inquiry card.

IMPERIAL–offers industry's most complete line of fittings and tools for steel, stainless steel, copper, aluminum and plastic tubing.

FLARELESS TYPE FITTINGS

HI-SEAL
Brass
Steel
Stainless Steel

HI-DUTY
Brass
Aluminum

FLEX
Brass

POLY-FLO
Brass

NYLO-SEAL
Nylon

ERMETO
Steel

COMPRESSION
Brass

FLARED TYPE FITTINGS

37 FLARE
Brass
Steel
Stainless Steel

45 HEAVY DUTY FLARE
Brass

45 FLARE AND INVERTED FLARE Brass

BRASS PIPE FITTINGS

PRESSURE HOSE AND REUSABLE COUPLINGS

Rubber Covered, Rayon Braid Hose — for low pressures.

Cotton Covered, Single Wire Braid Hose — for medium pressures.

Non-Skive Rubber Covered, Single Wire Braid Hose — for medium pressures.

Rubber Covered, Single Wire Braid Hose — for medium pressures.

Rubber Covered, Double Wire Braid Hose — for high pressures.

FLUID CONTROL AND SHUT-OFF VALVES

Needle Type
Toggle Type
Diaphragm Type
Plug Type
2, 3 and 4-way styles

TUBE WORKING TOOLS

CUTTERS
Tube Cutters
Sawing Vises

FLARING TOOLS
45 Flares
37 Flares
Double Flares

TUBE BENDERS
Lever Type
Gear Type
Spring Type

Reamers
Swaging Tools
Test Plugs and Caps
Refacing Tools

Emblem of Quality I

For more information on Valves and Tools circle **14** on inquiry card.

LETTERS—CONTINUED

just as fouled up in buying systems as are the process industries. Most potential clients are so accustomed to the "free" design pitch that they don't even know what is meant by "consultant." This brought out our brochure, the leading paragraph of which explains what we consultants do system-wise:

"Amber & Amber, a Michigan Co-Partnership, is an ethical consulting engineering firm, not to be confused with manufacturer's agents or sales representatives. Our role for manufacturing industry is similar to the role of consultants in the construction industry, who perform objective designs and investigations for their clients, without ties to the contractors or material suppliers. Amber & Amber always represent the clients, recommending the optimum system or equipment, regardless of the origin of the components."

While I am ordinarily against new committees and councils, I can see where the "Systems Engineering Council" you propose is really needed. It would be a right and timely move to straighten out the trend we are all in. So let's get the SEC rolling. Please publish the following announcement: we'll carry the ball from there.

George H. Amber
Amber & Amber
Consulting Engineers
Detroit 35, Michigan

An invitation to meet and discuss the need for a SYSTEMS ENGINEERING COUNCIL

1. WHEREAS systems firms have problems unique to their efforts, and
2. WHEREAS other companies that should be cooperating with systems firms are instead competing for systems work, and
3. WHEREAS the problems of systems engineering are much talked about but little understood, and
4. WHEREAS great confusion exists regarding the term systems engineering, and
5. WHEREAS systems firms have much to offer both industry and equipment manufacturers, and
6. WHEREAS systems engineering personnel have much to offer each other, and
7. WHEREAS the existence of a SYSTEMS ENGINEERING COUNCIL would point the way to clarification of all systems problems and the effecting of cooperation between systems firms and all other firms.

THIS IS A CALL FOR A MEETING TO EXAMINE THE NEED AND POSSIBILITY OF THE FORMATION OF A SYSTEMS ENGINEERING COUNCIL.

All persons engaged or interested in systems engineering work, at any level, are hereby invited to attend this meeting, which will be held at the Fourth International Automation Exposition, New York City Coliseum, June 10, 1958. 2:30 P.M., Room 415, Philippines Room. For further details contact:

George H. Amber
Amber & Amber
Consulting Engineers
19925 Schaefer Highway
Detroit 35, Michigan

Editor, I&A:

Congratulations on the 30th anniversary of *I&A*. I trust and hope you enjoy thirty more successful years of serving industry.

I read with interest your anniversary issue on Systems Engineering. I am more than a bit disappointed, however, that this issue did not include an article on the analog computer. Based on approximately seven years of personal effort in the Systems Engineering field, I am of the opinion that the analog computer is the one tool that makes the Systems Engineering concept of practical value.

I would also like to comment on the article "Computers in the Process Industries" by Williams, Johnson, and Rose. I suggest that some of the problems associated with the use of computers which are discussed in this article are the primary reasons why analog computers have such a bright future in the processing industries. The one example of the use of analog computers has an incorrect statement regarding the amount of equipment required. This exact simulation has been repeated at our Computation Center in Princeton, N. J. and required two amplifiers and one servo multiplier per distillation column plate.

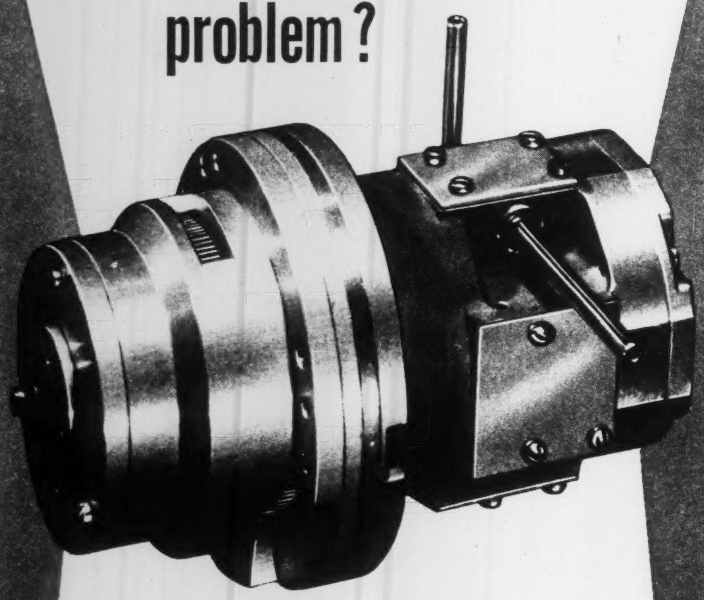
I suggest the oversight of omitting the analog story in your January issue is worthy of editorial comment.

C. W. Worley, Manager
Market Development Section
Electronic Associates
Long Branch, N. J.

For three full years, I&A has been pleading editorially and showing technically that SIMULATION is the

Continued on page 572

is this the missing component in your instrumentation problem?



AVIATION ELECTRIC'S NEW BALL RESOLVER

A new miniature calculator that has many applications in the general field of engineering design is currently being manufactured by Aviation Electric Limited of Montreal. The unit illustrated is being used with great success in Canada for the automatic calculation of sine; cosine and tangents in advanced navigational systems. Compact and light in weight, this resolver offers great accuracy of performance under the most rigorous conditions.

Based on a 19th century invention, the principle behind the new resolver is remarkable in its simplicity. Aviation Electric engineers, however, had to overcome many difficulties of design to develop a miniaturized instrument capable of instantaneous and continuous calculations to an accuracy greater than 0.3%, under conditions of great stress, with a temperature variation from +160°F. to −65°F.

Miniature resolvers are destined to play an important part in guided missile control and future technological advances of many kinds. Aviation Electric will be glad to discuss the application of this new ball resolver to your instrumentation problems and, if necessary, to design an entirely new unit for your purposes.

For further details and illustrated literature write to:

AVIATION ELECTRIC
LIMITED

200 LAURENTIEN BLVD., MONTREAL

HALIFAX • MONTREAL • OTTAWA • TORONTO • CALGARY • VANCOUVER

For more information circle **24** on inquiry card.

LETTERS—CONTINUED

key to systems analysis. We publish the Simulation Council Newsletter every month so that industry can learn how analog computers are being used. Our systems issue was designed to show how far from reality is that systems concept which is NOT based on a simulatable process. Nobody has done more to advance the cause of simulation in industry than has I&A, as the record shows.

Reader Inquiries

Transistorized Power Supply

Design engineer of development engineering company is seeking transistorized power supply with input voltage 6 to 12 volts dc; output voltage 450 volts dc; and enough power to charge 1050 μf capacitance in a maximum of 15 seconds. A-305

Photo-sensitive Aluminum Foil

Engineer with atomic power contracting company desires information of company which can supply photo-sensitive aluminum foil. A-306

Centrifugal Switch

President of lime works is seeking "alarm switch to indicate immediately the stopping of a rotating shaft." A-307

Spin Test Unit

Purchasing agent of turbine manufacturer wishes to receive information on complete units for testing turbine discs. A-308

Automatic Laboratory Balance

Manager of laboratory in Australian sugar refinery is seeking source of supply for automatic laboratory balance used in chemical analysis. A-309

Clamp-on Ammeter for DC

Publisher's researcher is interested in obtaining of manufacturers of d-c type clamp-on ammeters. A-310

Adhesion of Enamel Coatings

Exporter is seeking source of supply of instrument which determines strength of adhesion of enamel coating to metal base. Purportedly has needle shaped feelers to "determine number of electric-circuit closing." A-311

JUST AS GREAT IN EITHER SHAPE

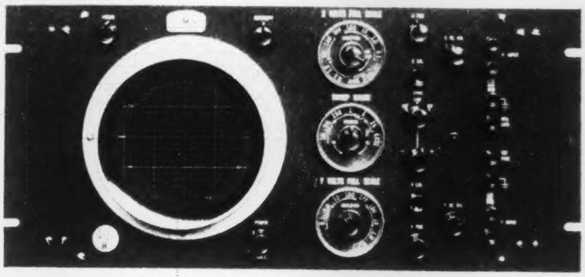
One of the 100 *Series*

the same big benefits you get in the Type 401 Bench Model are in rack-mounting form

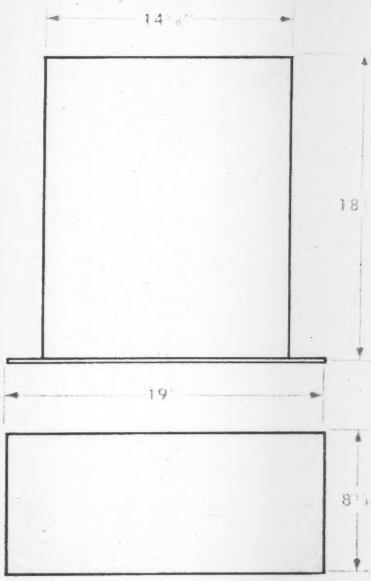
Du Mont

401-R

Rack-Mounted Oscilloscope



Identical in every electrical respect to its industry standard counterpart, the 401-R is physically rearranged for insertion into standard 19" relay racks. For quantitative and qualitative studies within the dc to 100 kc bandwidth, the 401-R offers important advantages in an easy-to-use configuration for panel operation. Some of these features... not available in other rack mountable units... are:



- X and Y amplifiers *identical* in all respects.
- Less than 3° phase shift between amplifiers at 100 kc. Even less phase shift at lower frequencies.
- Complete flexibility of sync control. Will sync from either positive or negative signals.
- Driven or recurrent sweeps available from front panel.
- Fast sweep — down to 10 us/inch.
- *Specified* linearity — any 10% increment of on-screen display is within 10% of any other increment.
- 5ADP cathode-ray tube for maximum light output at its 3 kv accelerating potential. No spot "blooming" with increases in brightness intensity.
- Direct access to deflection plates by terminals brought out at rear.
- Only 110 watt power consumption.
- "Channelized" controls. No doubled-up sweep and amplifier controls.

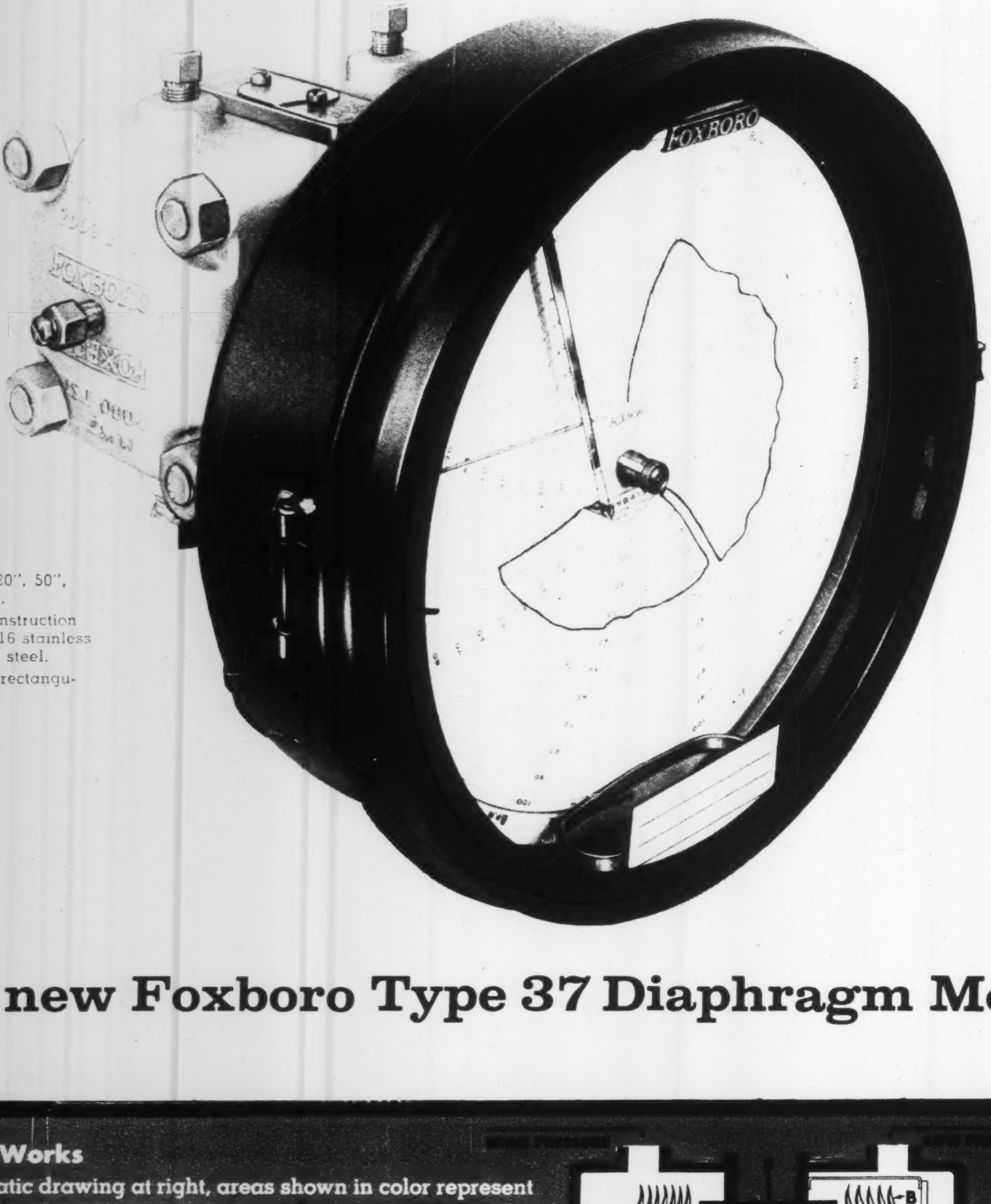
PRICE **$495.00**

Write for complete details...

DU MONT *Instrument Division*
ALLEN B. DU MONT LABORATORIES INC., CLIFTON, N. J., U. S. A.

For more information circle **16** on inquiry card.

NOW... a "Dry" Flow Meter with ...

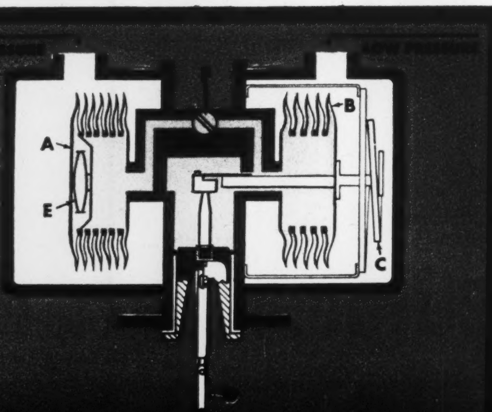


- Ranges: 20", 50", 100", 200".
- Forged construction in Type 316 stainless or carbon steel.
- Round or rectangular cases.

...the new Foxboro Type 37 Diaphragm Meter

How It Works

In schematic drawing at right, areas shown in color represent a stable, non-freezing liquid. Any pressure increase in the high pressure chamber compresses Diaphragm Unit A, displacing its liquid and expanding Diaphragm Unit B until force of Range Spring C equals the difference between the forces on Diaphragm Units A and B. Linear motion of Diaphragm Unit B moves inner end of Drive Bar D — outer end moves correspondingly through the bellows-sealed flexure bar, driving pen arm. Built-in Temperature Compensator (E) proportionately adjusts diaphragm capacity as ambient temperature variations affect volume of filling fluid. External damping adjustment is shown at F.



•*complete overrange protection!*

•*sustained high accuracy!*

Now you can have mercuryless flow measurement for a wide range of differential pressures — at static pressures up to 2000 psi — with greater safety and dependability than ever before! The new Foxboro Type 37 Diaphragm Meter not only combines unmatched ruggedness and precision in a dry meter — it's by far the easiest to adjust and maintain. And it does away with zero drift problems, once and for all! Expansible, Type 316 S.S. diaphragm elements respond to changes in pressure with unmatched sensitivity, yet are completely immune to overrange up to full static pressure! A unique packless drive bar precisely transmits linear motion to the pen arm. Range-changing is easy, due to new twin-spiral spring design. Wide range damping is externally adjustable under pressure. And the Type 37 is self-compensating for temperature changes in all differential ranges. Get full details on this high utility, completely dependable dry flow meter. Arrange for a demonstration with your nearby Foxboro Field Engineer, or write

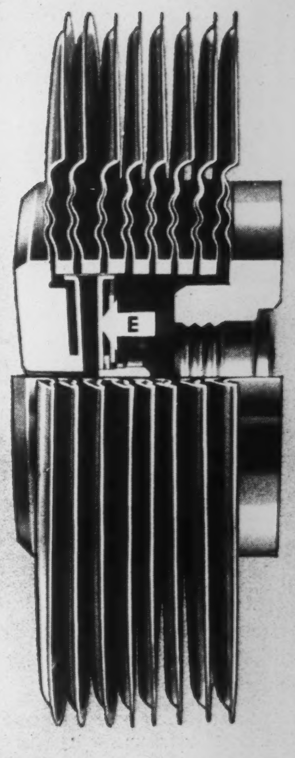
The Foxboro Company, 464 Neponset Ave., Foxboro, Mass., U.S.A.

FOXBORO

REG. U.S. PAT. OFF.

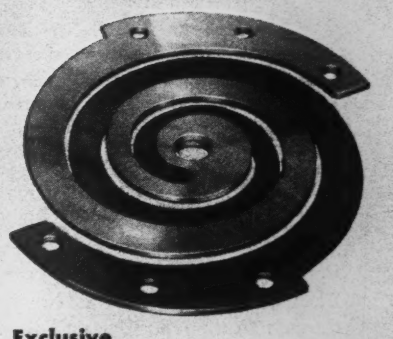
FIRST IN FLOW METERING

For more information circle 17 on inquiry card.



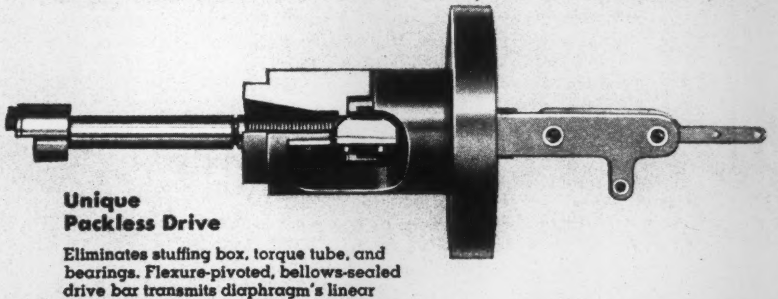
Exclusive Diaphragm Elements

Type 316 S.S. diaphragm units in both high and low pressure chambers provide greatest linearity and freedom from hysteresis; nesting design and integral spacer rings provide safe, positive, overrange protection. Temperature compensation (E) is built into diaphragm assembly . . . never requires change or adjustment.



Exclusive Range Springs

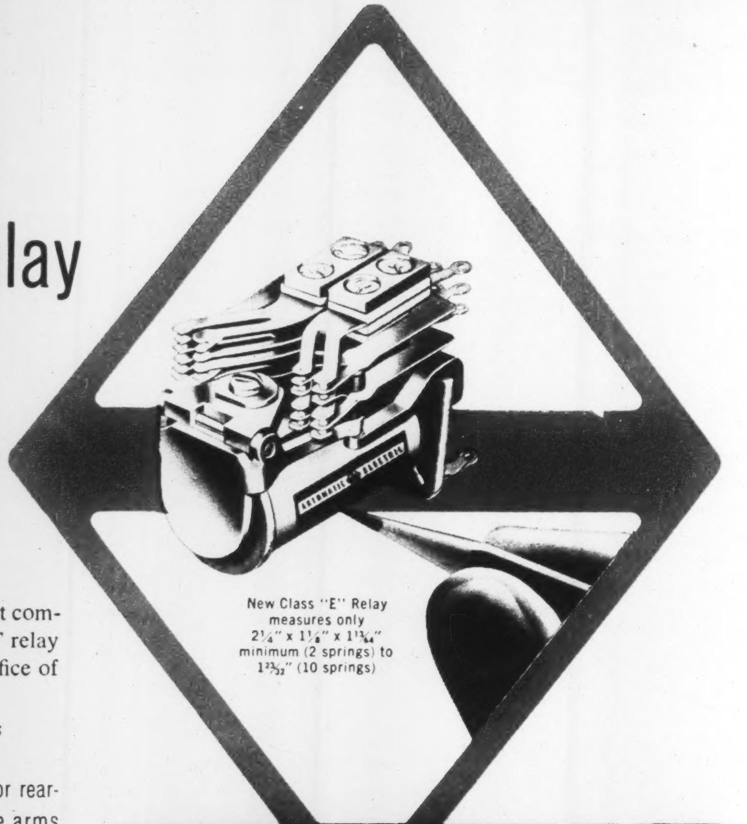
Heavy gauge Ni-Span C alloy, twin-spiral springs provide high sensitivity with lasting accuracy. Readily accessible . . . range changes are easily made, in minutes!



Unique Packless Drive

Eliminates stuffing box, torque tube, and bearings. Flexure-pivoted, bellows-sealed drive bar transmits diaphragm's linear motion to the pen arm with unequalled sensitivity *and undiminished* power. Seal for flexure pivot is a tough, flexible bellows.

a LOT of Relay in a little space



New Class "E" Relay measures only $2\frac{1}{4}'' \times 1\frac{1}{8}'' \times 1\frac{13}{64}''$ minimum (2 springs) to $1\frac{23}{32}''$ (10 springs)

This latest Automatic Electric achievement compacts all the features of the famous Class "B" relay in minimum space and weight—with no sacrifice of quality or ruggedness.

LOOK AT THE IMPORTANT FEATURES THIS NEW CLASS "E" OFFERS:

• miniaturized; telephone-style base mounting for rear-connected wiring • heavy-thickness armature arms prevent loss of stroke with large pileups • heavy-duty backstop that won't break or wear out • adequate terminal clearances for easy wiring • long-life, lubricant-retaining bearing arranged to provide a visual check of the heelpiece airline setting without disturbing the adjustment • twin contacts standard; all springs bifurcated for maximum independence • sturdy, strain-relieved heelpiece insures stability of adjustment

Class "E" Relays are available in the following series:

EQA—Quick Acting	**ESA**—Slow Acting*
ESO—Slow Operate	**EFA**—Alternating Current
ESR—Slow Release	**EMS**—Snap Action Contacts

**slow operate and slow release*

Class "E" Relays can be supplied plug-mounted (with or without cover) or hermetically sealed (maximum 4 springs per pileup) in enclosure AE-3300.

• • •

For more information, call or write Automatic Electric Sales Corporation, Northlake, Illinois. *In Canada:* Automatic Electric Sales (Canada) Ltd., Toronto. *Offices in principal cities.*

99% pure isn't pure enough—the relay iron we use at Automatic Electric must meet specifications of 99.8% purity, including, for example, carbon content limit of .02. To obtain highest magnetic permeability, material is treated for periods up to 7 hours in roller hearth annealing furnaces. Highest standards of quality control insure the well-known dependability of AE Relays and Switches.

AUTOMATIC ELECTRIC

Northlake, Illinois

Subsidiary of **GENERAL TELEPHONE**

For more information circle **52** on inquiry card.

trends

Interest in foreign instrument markets is growing. Here is exclusive report on Australian instrument industry: Most instrument makers are represented. But, while the American companies can do a small special business, the currency keeps them out. Three small firms make switchboard instruments but nobody makes temperature controllers. Time seems ripe for a start, but it would have to be on some percentage basis with an existing Australian Company. Industry is growing and they seem to make almost everything except control instruments.

Report on Turkish Instrument Market: Turkey imports all instruments, industrial and scientific. One factory is being started to make water meters and gas meters. Watt-hour meters come from Austria, Yugoslavia or Germany.

Report on Israel instrument industry: No instrument manufacturing industry yet exists, but a great deal of industrial activity and interest in instrumentation.

More than 420 international scientific conferences were held in 1957, with an increasing number being scheduled for Moscow. U. S. ban on Red Chinese and other Communist scientists is causing groups to shun U. S. as meeting place, to choose Paris, Rome, or Moscow.

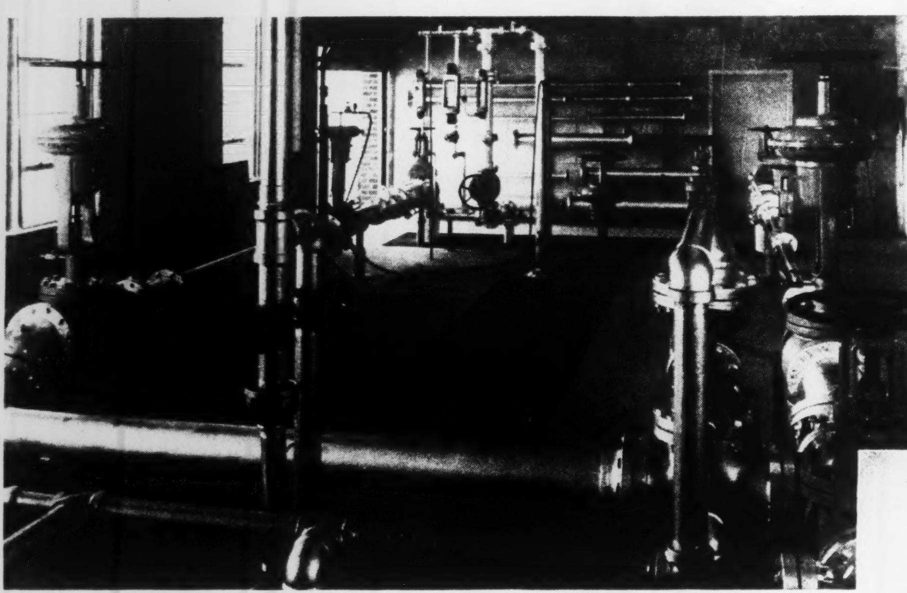
Total annual instrument market represented by U. S. Colleges and universities offering physics majors is probably not less than $2 million, reports Committee on Apparatus for Educational Institutions of the American Association of Physics Teachers, which says that there are about 540 institutions in the United States which offer a physics major. To this market must be added potential sales to junior colleges and other institutions (of which perhaps 500 offer introductory courses in physics), sales to high schools, and sales of apparatus for general education courses.

Dept. of Health, Education and Welfare reports that from 1951 to 1955, average expenditures for elementary and high school education was about $9 billion per year, whereas $14 billion per year are needed only to maintain present standards in facilities, teachers pay, and number of teachers per pupil.

Lag in U. S. Apprentice Training threatens nation. Number training now (260,000) isn't even enough to replace journeymen who will retire or die next year, much less fill new needs of growing industry.

Instruments and related products industry employed 297,000 workers in 1956 compared to 283,000 in 1955; value added by manufacture in 1956 was $2.67 billion; compared to $2.37 billion in 1955—reports Department of Commerce in 1956 Census of Manufactures.

In this new lab...



Honeywell Valves *pass tougher tests than you'll ever give them*

In this brand-new Honeywell lab, test and inspection procedures are developed to insure the quality you *must* have in your control valves. Here, valves stand up under rigorous tests . . . far tougher than any testing you'll put them through.

Honeywell Quality Control Valves . . . sold and serviced in your local area . . . are available in a wide range of sizes and styles for use in process instrumentation.

Next time you need control valves . . . why not do as others are doing? Call your local Honeywell field engineer . . . he's as near as your phone . . . or write for literature and delivery information.

MINNEAPOLIS-HONEYWELL, Fort Washington, Pennsylvania.

Honeywell

H HONEYWELL *First in Controls*

ASCO

one source for the most complete line of SOLENOID VALVES

When you discuss solenoid valve requirements with an ASCO Engineer, you are benefiting from the design and development experience of half a century. The ASCO specialist can recommend the *right* valve for your needs because that leadership has resulted in the more than 1300 types of solenoid valves now available:

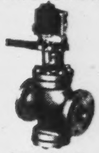
> Two way valves in pipe sizes from 1/8" to 6" — for temperatures to 600° F. — for pressures to 1500 p.s.i.
>
> Three way valves in pipe sizes from 1/8" to 6" — for temperatures to 450° F. — for pressures to 1000 p.s.i.
>
> Four way valves in pipe sizes from 1/4" to 1 1/2" — for temperatures to 212° F. — for pressures to 500 p.s.i. — poppet or slide type.

And ASCO can supply you with standard, explosion-proof or water tight enclosures — Class A and Class H coils — a wide range of body materials including cast iron, brass, bronze and stainless steel.

There's *one* source that solves virtually any solenoid valve problem — ASCO. Why not have the ASCO Engineer call — or write for your copy of ASCO Solenoid Valve Catalog No. 201.

MANUAL RESET

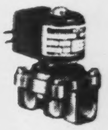
Electrically tripped
Bulletin 8015


Safety shut-off, no voltage release
Bulletin 8025

"Free handle" safety shut off
Bulletin 8020

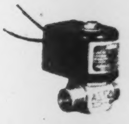
TWO WAY – FULL PORTED

Low pressure
Bulletin 8030

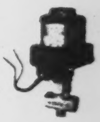

General purpose
Bulletin 8210A

Steam
Bulletin 8222

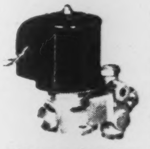
TWO WAY – SMALL PORTED

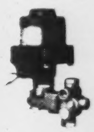

Midget general purpose
Bulletin 8262

Fuel oil and gas
Bulletin 8268


Explosion proof
Bulletin 8269

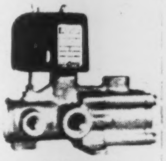
THREE WAY

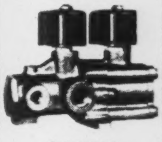

Pilot control of diaphragm or cylinder
Bulletin 8300

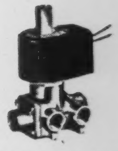

Explosion proof
Bulletin 8302

Midget, general purpose
Bulletin 8314

FOUR WAY

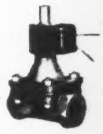

Single solenoid
Bulletin 8344


Dual solenoid
Bulletin 8344

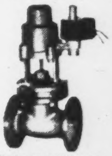

Midget, general purpose
Bulletin 8345

CORROSION RESISTANT

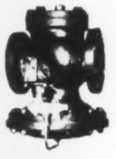
Cylinder operated, Saunders body
Bulletin 8336


Compact Saunders type
Special Bulletin 8336

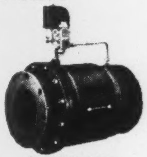
Three way
Special Bulletin 8300

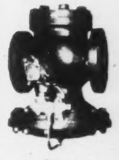

Cylinder operated, many body materials
Bulletin 8338

PILOT CONTROLLED


Water and gas
Bulletin 8333

Three way
Bulletin 8331


Expansible sleeve
Bulletin 8335


Steam
Bulletin 8334

SPECIAL PURPOSE

Sanitary type
Bulletin 8337

Pressure operated, manual reset
Bulletin 8035

Bulk loading, electrical interlock
Bulletin 8023

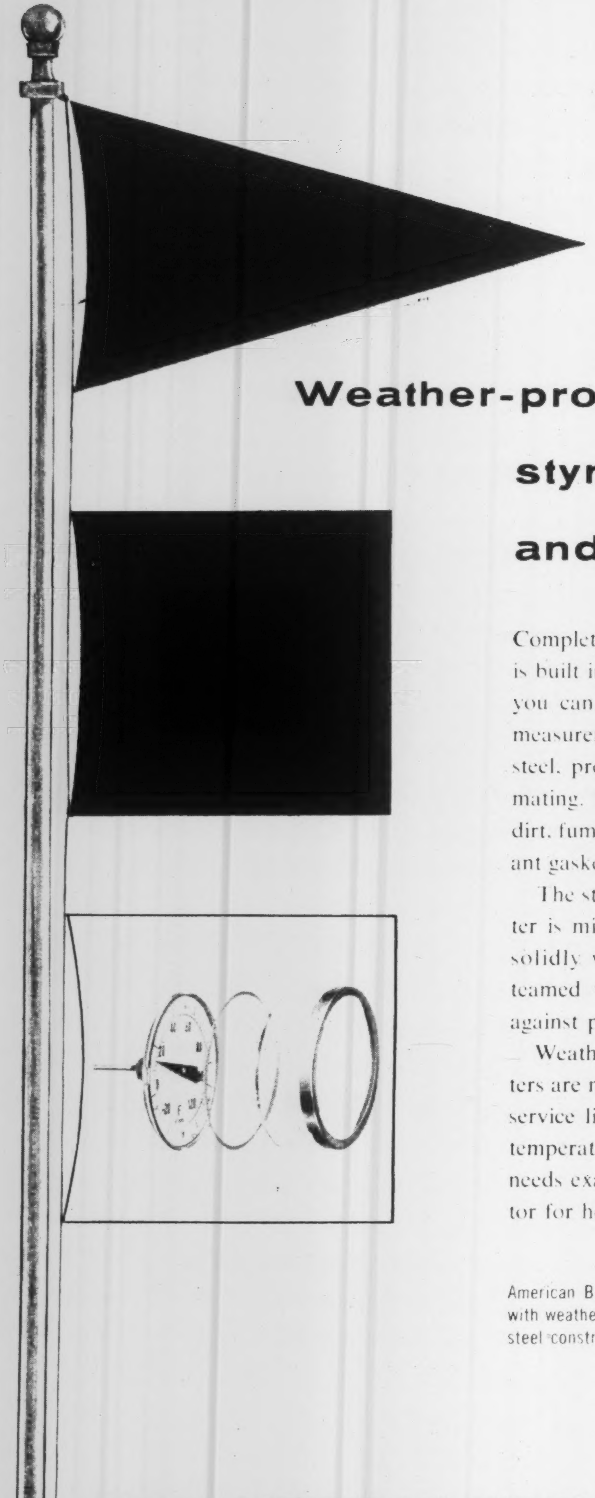
Drain valve, washing machine
Bulletin 8339

ASCO

Automatic Switch Co.

52-F Hanover Road, Florham Park, New Jersey
FRontier 7-4600

For more information circle **101** on inquiry card.



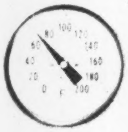
Weather-proof construction stymies erosion and corrosion

Complete protection against erosion and corrosion is built into American Bi-Metal Thermometers, so you can always be sure of accurate temperature measurement. Both case and bezel are stainless steel, precisely fitted and gasketed to insure snug mating. Whatever the weather, rain, sand, dust, dirt, fumes and frost are sealed out by a heat-resistant gasket between case and thick cover glass.

The stem of the American Bi-Metal Thermometer is mirror-smooth stainless steel. All joints are solidly welded. Top resistance to corrosion is teamed with strength, rigidity and tight closure against process pressures.

Weather-proof American Bi-Metal Thermometers are noted for high sustained accuracy and long service life. There are mounting styles, dial sizes, temperature ranges and stem lengths to meet your needs exactly. Ask your industrial supply distributor for help in proper selection.

American Bi-Metal Thermometer with weather-proof stainless steel construction.



MAXWELL
MANNING
M&M
& MOORE INC.
TRADE MARK

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A product of
MANNING, MAXWELL & MOORE, INC.

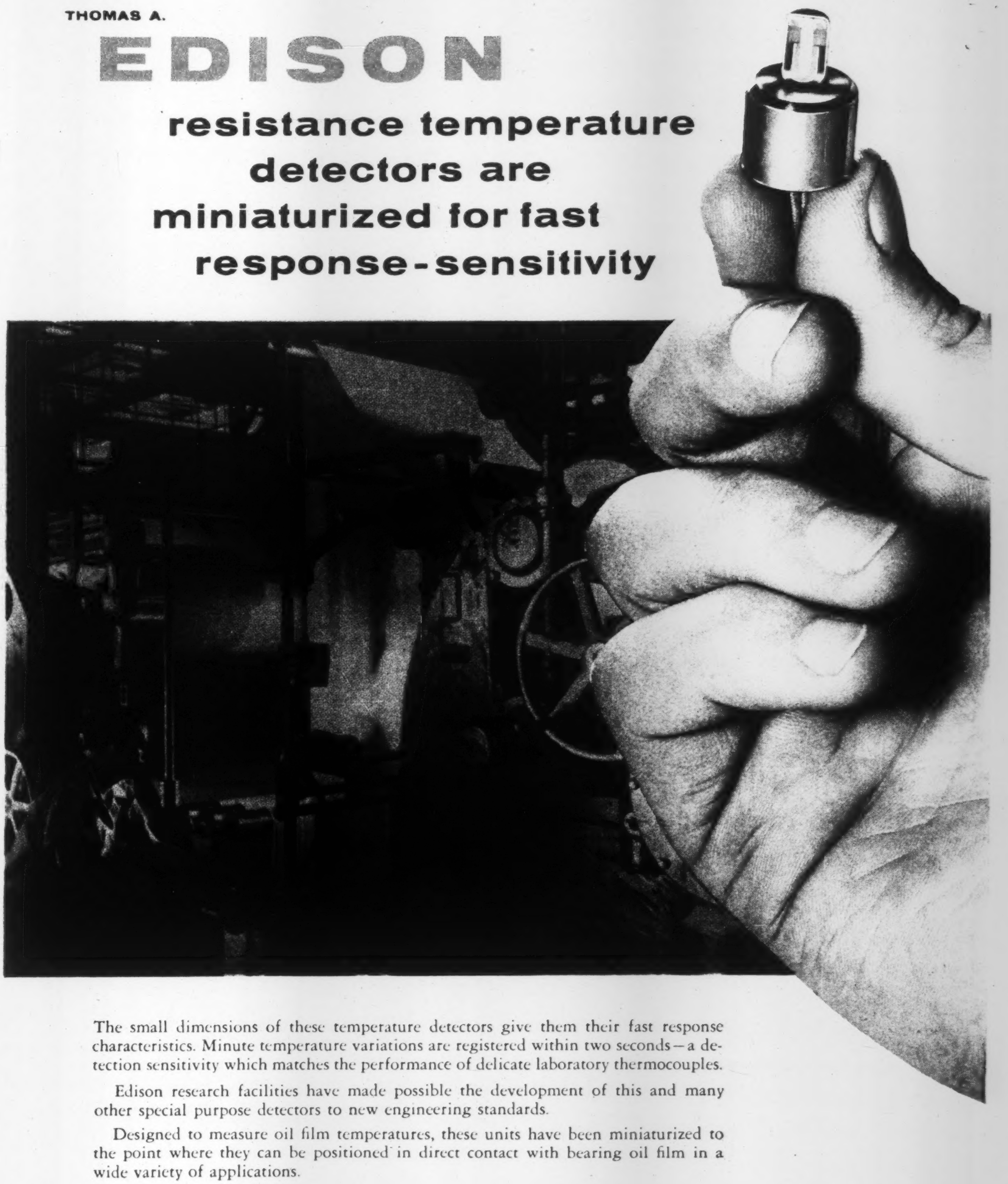
Consolidated Ashcroft Hancock Division • Stratford, Connecticut
In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

For more information circle 21 on inquiry card.

THOMAS A.

EDISON

resistance temperature detectors are miniaturized for fast response-sensitivity



The small dimensions of these temperature detectors give them their fast response characteristics. Minute temperature variations are registered within two seconds—a detection sensitivity which matches the performance of delicate laboratory thermocouples.

Edison research facilities have made possible the development of this and many other special purpose detectors to new engineering standards.

Designed to measure oil film temperatures, these units have been miniaturized to the point where they can be positioned in direct contact with bearing oil film in a wide variety of applications.

For complete information on Edison Resistance Temperature Detectors, write for Bulletin No. 3016.

Thomas A. Edison Industries
INSTRUMENT DIVISION

24 LAKESIDE AVENUE, WEST ORANGE, N. J.

For more information circle **22** on inquiry card.

news

I&A Readers to Get Full Coverage of Overseas Instrumentation Developments

PITTSBURGH, PA.—Readers of I&A always have enjoyed this country's best reporting service on new products and new literature (the New Product and New Literature sections of I&A are more complete than those of all other instrument journals in this country *combined*). Plans have now been made for equally comprehensive coverage of overseas developments.

Last fall, publisher Rimbach traveled to Europe and met with the editors of a number of instrumentation and automation magazines abroad. Reciprocal arrangements have now been concluded with the editors of overseas publications listed here. Each will be on the lookout for information in his field, and act as foreign correspondent for *Instruments & Automation* in his respective country:

Dr. Jan Obalski, Editor, *Pomiary-Automatyka-Kontrola*
Dr. Antonio Barbiere, Editor, *Revista Strumentazione e Automazione*
Dr. Hans Sartorius, Editor, *Regelungstechnik*
Leo Brandenberger, Editor, *Archiv fuer Technisches Messen* and *Industrielle Messtechnik*
Dr. Jean Virié, Editor, *Mesures & Controle Industriel*
Dr. Vladimir Muljevic, *Professor of Electrical Engineering, University of Zagreb*
J. T. Miller, Editor, *Instrument Practice*

This will provide an increased service to our readers. Valuable research and other data in the field of instrumentation and automation appear in foreign periodicals in this field. As a further service to I&A readers, the Instruments Publishing Company has arranged to accept subscriptions for the following publications:

Mesures & Controle Industriel (French) monthly	$10.00 per annum
Regelungstechnik (German) monthly	$12.00 per annum
Archiv fuer Technisches Messen and Industrielle Messtechnik (German) monthly	$10.00 per annum
Strumentazione e Automazione (Italian) monthly	$14.00 per annum
Pomiary-Automatyka-Kontrola (Polish)	$6.00 per annum

Color-coded Panel Tubing Standard Proposed

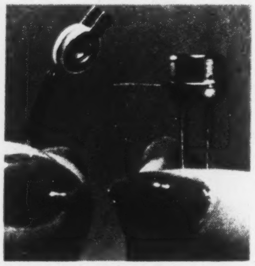
PITTSBURGH, PA.—A new issue of ISA Recommended Practices suggests color coding of pneumatic tubing on instrument panels. In essence the code urged for industry-wide adoption is: air supply—*red;* seal—*purple;* set—*black;* alarm—*green;* readout—*blue;* transmitted—*orange;* controlled—*yellow;* all others—*natural.*

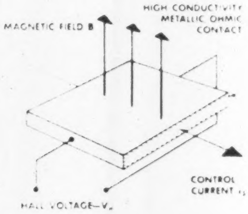
Revolutionary New Electronic Components

PITTSBURGH, PA.—The electronic world is progressing fast. Here are five "basic" developments:

- **BELL LABS** reports from New York: A new experimental device, known as the *field-effect varistor,* is a passive semiconductor component with constant-current feature and very high a-c impedance. Closely related to the field-effect transistor it contains a single planar junction which is achieved by diffusion.

- **GENERAL ELECTRIC** reports from Schenectady: A new titanium-ceramic electron tube, not much larger than a shirt button, that operates up to 1500° F and contains no heater (heat is provided by environment).


GE titanium ceramic electron tube



Westinghouse Semiconductor Hall Generator

- **WESTINGHOUSE ELECTRIC** reports from Pittsburgh: A tiny semiconductor *Hall Generator* has been developed using two semiconductors, indium antimonide and indium arsenide, to provide a voltage output proportional to the product of (1) the current passing through it, and (2) the magnetic field perpendicular to it. Known as the Hall effect since 1879, the properties of this new solid-state multiplying device suggest use as an analog computer element. Output Hall voltages of 0.5 v are obtained with 5-kilogauss field and 0.5-amp control current.

  Two new "true-power" silicon transistors (*Trinistors*) also have been disclosed by Westinghouse. Ultrapure silicon and new fabrication techniques have made possible (1) a 2 to 5 amp unit that can handle power up to 1 kw, and (2) a 10 to 20 amp unit able to handle power up to 3 kw. Operation is similar to thyratron operation with 40 x 10^{-9} second reaction time—and current can be cut off by pulse to the control electrode.

- **SHOCKLEY SEMICONDUCTOR LAB** of Beckman Instruments reports from Los Angeles: A new electronic revolution may be in the making with the *transistor diode.* In describing the difference between the conventional transistor and the new *four-layer diode,* Dr. William Shockley told the recent Transistor and Solid-State Circuits Conference in Philadelphia that "both lower costs and superior preformance may result from replacing transistors with transistor diodes."

- **TEXAS INSTRUMENTS INC.** announces the "Sensistor," a silicon resistor with a large positive temperature coefficient.

FREQUENCY STANDARDS

PRECISION FORK UNIT
TYPE 50

Size 1" dia. x 3¾" H. Wght., 4 oz.*

Frequencies: 240 to 1000 cycles
Accuracies:—
  Type 50 (±.02% at —65° to 85°C)
  Type R50 (±.002% at 15° to 35°C)
Double triode and 5 pigtail parts required
Input, Tube heater voltage and B voltage
Output, approx. 5V into 200,000 ohms

*3⅛" high
400 - 1000 cy.

FREQUENCY STANDARD
TYPE 50L

Size 3¾" x 4½" x 5½" High
Weight, 2 lbs.

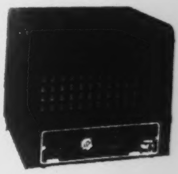
Frequencies: 50, 60, 75 or 100 cycles
Accuracies:—
  Type 50L (±.02% at —65° to 85°C)
  Type R50L (±.002% at 15° to 35°C)
Output, 3V into 200,000 ohms
Input, 150 to 300V, B (6V at .6 amps.)

PRECISION FORK UNIT
TYPE 2003

Size 1½" dia. x 4½" H. Wght. 8 oz.*

Frequencies: 200 to 4000 cycles
Accuracies:—
  Type 2003 (±.02% at —65° to 85°C)
  Type R2003 (±.002% at 15° to 35°C)
  Type W2003 (±.005% at —65° to 85°C)
Double triode and 5 pigtail parts required
Input and output same as Type 50, above

*3½" high
400 to 500 cy.
optional



FREQUENCY STANDARD
TYPE 2005

Size, 8" x 8" x 7¼" High
Weight, 14 lbs.

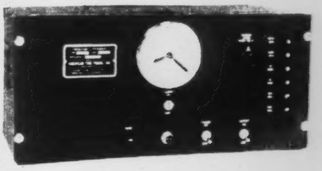
Frequencies: 50 to 400 cycles
(Specify)
Accuracy: ±.001% from 20° to 30°C
Output, 10 Watts at 115 Volts
Input, 115V. (50 to 400 cycles)

FREQUENCY STANDARD
TYPE 2007-6

NEW

TRANSISTORIZED, Silicon Type
Size 1½" dia. x 3½" H. Wght. 7 ozs.

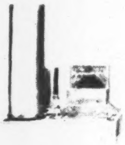
Frequencies: 400 — 500 or 1000 cycles
Accuracies:
2007-6 (± .02% at —50° to +85°C)
R2007-6 (±.002% at +15° to +35°C)
W2007-6 (±.005% at —65° to +125°C)
Input: 10 to 30 Volts, D. C., at 6 ma.
Output: Multitap, 75 to 100,000 ohms



FREQUENCY STANDARD
TYPE 2121A

Size
8¾" x 19" panel
Weight, 25 lbs.

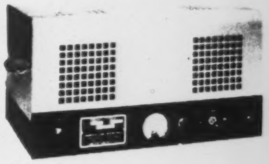
Output: 115V
60 cycles, 10 Watt
Accuracy:
±.001% from 20° to 30°C
Input, 115V (50 to 400 cycles)



FREQUENCY STANDARD
TYPE 2001-2

Size 3¾" x 4½" x 6" H., Wght. 26 oz.

Frequencies: 200 to 3000 cycles
Accuracy: ±.001% at 20° to 30°C
Output: 5V. at 250,000 ohms
Input: Heater voltage, 6.3 - 12 - 28
B voltage, 100 to 300 V., at 5 to 10 ma.



FREQUENCY STANDARD
TYPE 2111C

Size, with cover
10" x 17" x 9" H.
Panel model
10" x 19" x 8¾" H.
Weight, 25 lbs.

Frequencies: 50 to 1000 cycles
Accuracy: (±.002% at 15° to 35°C)
Output: 115V, 75W. Input: 115V, 50 to 75 cycles.

ACCESSORY UNITS
for TYPE 2001-2

L—For low frequencies multi-vibrator type, 40-200 cy.
D—For low frequencies counter type, 40-200 cy.
H—For high freqs, up to 20 KC.
M—Power Amplifier, 2W output.
P—Power supply.

This organization makes frequency standards within a range of 30 to 30,000 cycles. They are used extensively by aviation, industry, government departments, armed forces—where maximum accuracy and durability are required.

WHEN REQUESTING INFORMATION
PLEASE SPECIFY TYPE NUMBER

American Time Products, Inc.

Watch Master
Timing Systems

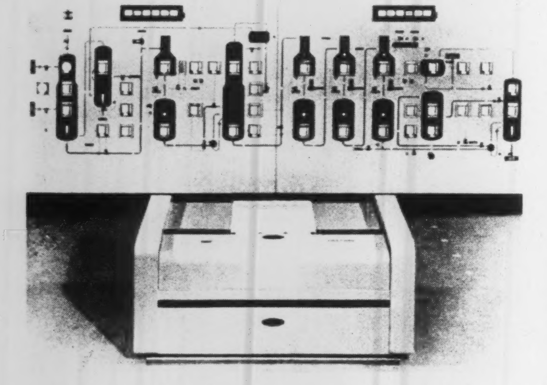
Telephone: PLaza 7-1430

580 Fifth Ave., New York 36, N. Y.

For more information on: Frequency Standards circle **23** on inquiry card; Fork Units circle **138**.

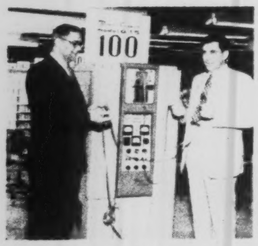
Automation at Brussels Fair

NEW YORK, N. Y.—An automation exhibit featured in the U. S. pavilion at the coming Brussels Fair will show Europeans the model of an oil refining process—a Kellogg Catalytic Reforming Unit that duplicates in miniature a "Cat" reformer now producing high octane gasoline components in an Illinois refinery. The graphic control panel was engineered by the M. W. Kellogg Co. and specially built for the Fair by Panellit. A new Panellit Data Logger will also be shown as an example of the latest refinery equipment designed to automatically monitor information and prepare permanent log sheet records.

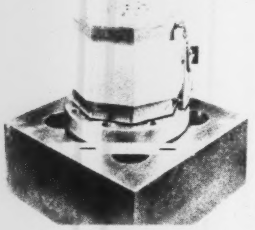


News Bits

BENDIX COMPUTER DIV., reached an historic milestone in the computer industry when its 100th general purpose computer rolled off the assembly line recently. No less important to the computer industry than the manufacture of the one millionth automobile pulled off a Detroit assembly line, the centennial machine was fitted with a gold plated metal exterior.



Bendix's 100th G-15



Wyle's "Hydrashaker"

WYLE MFG. CO. announces delivery of high-force, high-frequency vibration test machines, the "Hydrashaker," one to the U. S. Navy and one to North American Aviation, Inc. The machine employs a new principle of electronically-controlled hydraulic power.

PIC DESIGN CORP. announces acquisition of a precision tool component line from **VON INDUSTRIES, INC.**

ELECTRONIC ASSOCIATES reports growth in 1957 despite national slump: Sales rose nearly 40% to almost $12,300,000 resulting in a net profit after taxes of slightly more than one million dollars. The backlog of $6.6 million which by the end of 1957 had dropped to $4.6 million has climbed in recent weeks again to $5.6 million.

LEEDS & NORTHRUP'S Manager Market Development Div., Nathan Cohn, received a second prize at the Winter Meeting of the AIEE for his paper "Some Aspects of Tie-Line Bias Control on Interconnected Power Systems."

L&N's Nat Cohn

M-H's Jim Locke

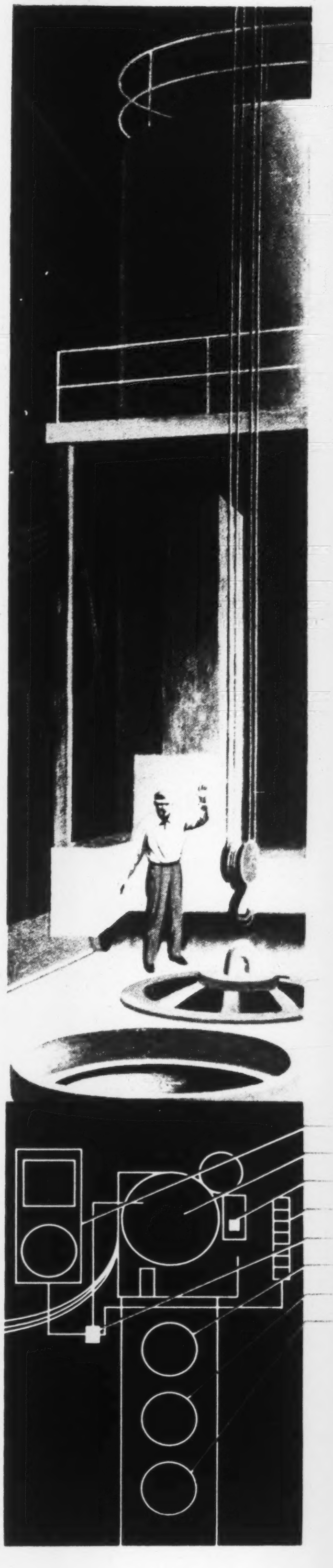
The jumbo-size, automatically-operated slide rule shown is offered as proof that automation begins at home. Designed by engineers at **MINNEAPOLIS-HONEYWELL,** it performs its mathematical steps with push-button ease. An electric motor triggers a small "brain" which maneuvers the three-foot-long slide rule into calculating position. The unique device—a leg-pull, but it does work!—was a gift to factory manager Jim Locke, shown here operating his present.

INTERNATIONAL CONFERENCE FOR ANALOG COMPUTATION will be held in Strasburg, France, for one week beginning September 1. For information contact M. F. H. Raymond, c/o S.E.A., 138 Boulevard de Verdun, Courbevoie (Seine), France.

CONFERENCE ON ELECTRONIC STANDARDS AND MEASUREMENTS co-sponsored by AIEE, IRE, and NBS at Boulder, Colorado, will devote three days this summer to technical sessions and inspection trips through the Boulder Laboratories.

H. Sherid Garrett

H. Sherid Garrett, manager of Moore Products Co.'s Application Engineering Dept., died at the age of 42 on February 27, 1958. He was author of a number of technical papers and magazine articles on process measurement and control, and gave lectures before ISA sections and technical meetings in all parts of the country. A graduate of Drexel Institute, he had been associated with B. F. Goodrich Co., and Barrett Div. of Allied Chemical and Dye Co. before joining Moore Products Co. in 1944.

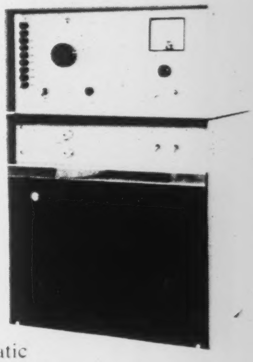


precise furnace atmosphere control

Accurate, continuous atmosphere monitoring means higher furnace yield —faster instrument payout

Now you can increase heat-treating furnace yield with accurate analyses of atmosphere gases and moisture content. With CEC instrumentation you can monitor atmospheres continuously and be assured that each furnace load is treated precisely according to a predetermined formula. Maximum furnace yields result in lower product costs . . . and fast instrument payout.

Two instruments—a gas analyzer and moisture monitor—can be used individually or as part of a complete instrumentation system . . . CEC engineers design installations for any requirement.



CEC's 21-611 mass-spectrometer-type gas analyzer is rugged and can be operated by semi-skilled personnel with a minimum of instruction.

With this versatile, inexpensive instrument a whole spectrum of gases can be analyzed such as hydrogen, oxygen, carbon monoxide, methane, nitrogen, carbon dioxide, hydrogen cyanide, argon, etc.

The 21-611 covers mass range 2 through 80, with automatic scanning from mass 12 through 40 requiring only 3 minutes. For complete information, contact your nearest CEC Field Office or write for Bulletin CEC 1843-X7.

CEC's new extended-range Moisture Monitor 26-302

For monitoring or control of trace quantities of moisture in gases or gaseous mixtures. Range: less than 1 ppm to 20,000 ppm. Write for Bulletin CEC 1834-X22.

SEE FOR YOURSELF . . .
CEC's Application Engineers are available to design and install complete systems for monitoring furnace atmospheres.
Contact your nearby CEC Field Office.

Analytical & Control Instrument Division

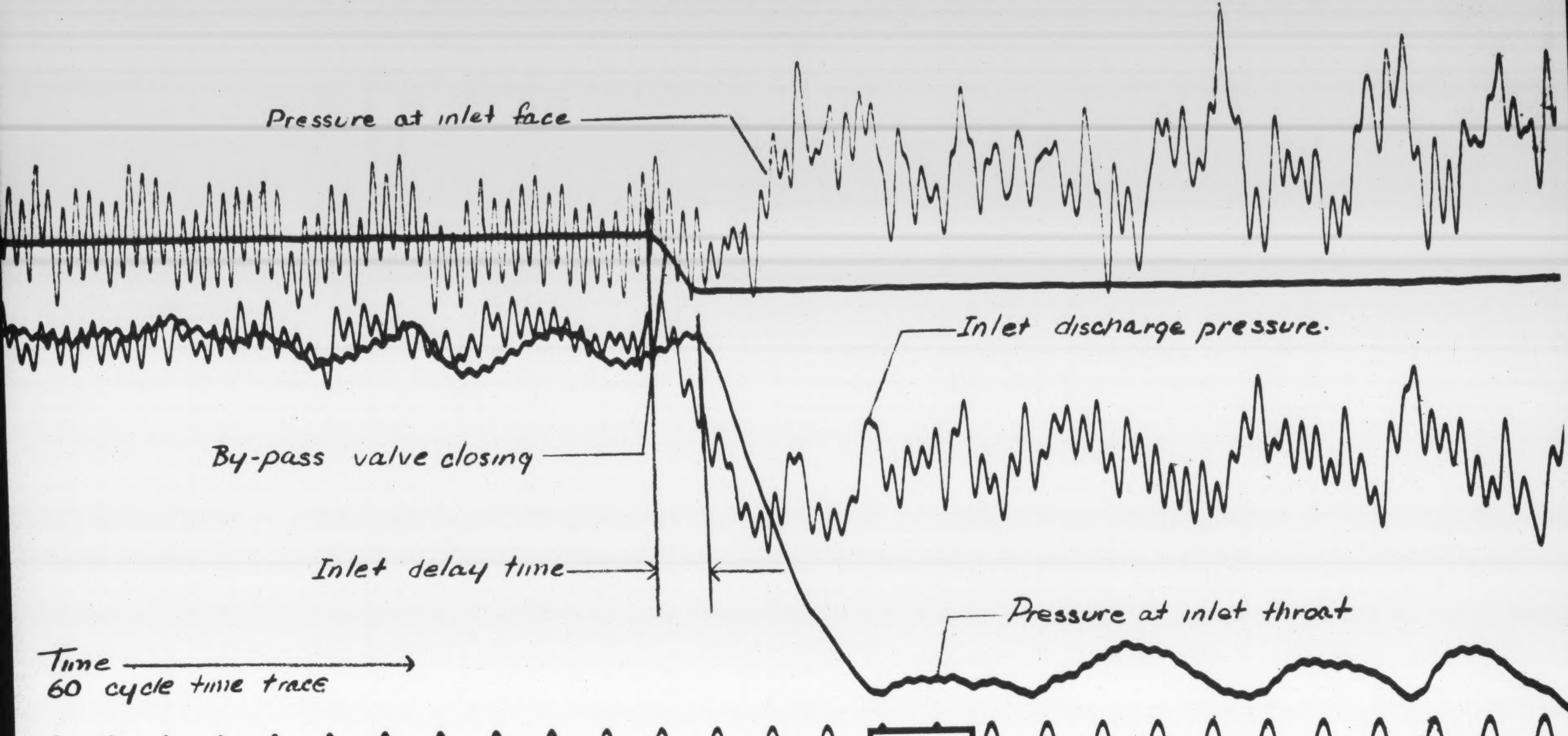
Consolidated Electrodynamics

300 North Sierra Madre Villa, Pasadena, California

CEC

OFFICES IN PRINCIPAL CITIES THROUGHOUT THE WORLD

For more information circle **25** on inquiry card.


Pressure at inlet face
Inlet discharge pressure.
By-pass valve closing
Inlet delay time
Pressure at inlet throat
Time
60 cycle time trace

this

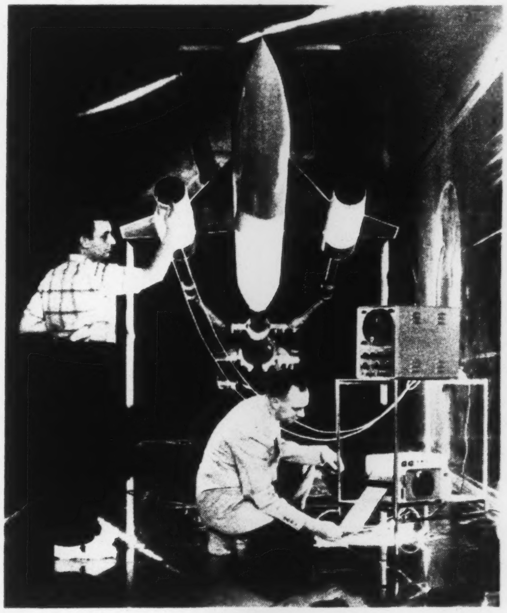
The Visicorder charts pressure fluctuations in a supersonic inlet

A Model 906 Honeywell Visicorder wrote this record of pressure fluctuations . . ."buzz". . . for the National Advisory Committee for Aeronautics at the Lewis Flight Propulsion Laboratory in Cleveland. Buzz is the term used to describe unsteady variation in pressure and airflow characteristics of a supersonic aircraft or missile inlet.

The purpose of these Visicorder studies is to define the buzz-free operating limits of the inlet, and to provide the designer with structural load information in case the inlet is inadvertently caused to operate on buzz during flight. This is particularly important because inlet buzz can result in fluctuating structural loads of the order of 1000 psf. Depending on the inlet design, this could cause structural failure of the inlet and loss of the airplane.

High response pressure transducers are used to measure these fluctuating pressures and the resulting electrical signal is fed into the Visicorder. Records such as this are also necessary in the determination of the inlet dynamics such as delay time. This information is then used to design inlet control systems.

is a record of "BUZZ"



The HONEYWELL VISICORDER is the first high-frequency, high-sensitivity direct recording oscillograph. In laboratories and in the field everywhere, instantly-readable Visicorder records are pointing the way to new advances in product design, rocketry, computing, control, nucleonics . . . in any field where high speed variables are under study.

To record high frequency variables—and monitor them as they are recorded—use the Visicorder Oscillograph. Call your nearest Minneapolis-Honeywell Industrial Sales Office for a demonstration.

Reference Data: Write for Visicorder Bulletin.
Minneapolis-Honeywell Regulator Co.,
Industrial Products Group, Heiland Division
5200 E. Evans Ave., Denver 22, Colo.

MINNEAPOLIS
Honeywell
Heiland Division

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Cloth bound with dust jacket, 5½ x 8½, 394 pages, ilustrated—$6.00 postpaid.

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[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
Wallace & Tiernan	[illegible]	[illegible]	[illegible]
Waltham Prec. Inst.	[illegible]	[illegible]	[illegible]

[illegible] Not Traded [illegible] Bid Asked

New York Stock Exchange:

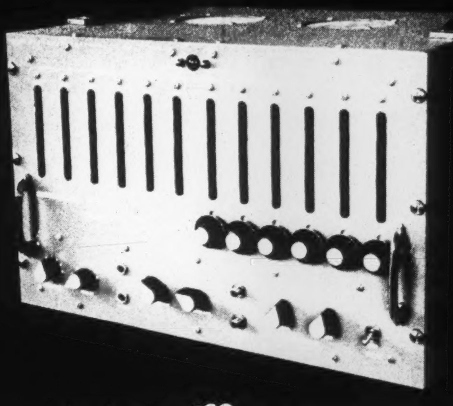
Price Range For [illegible]
Thru March [illegible]

	High	Low	Price as of [illegible]
ACF Industries	[illegible]	[illegible]	[illegible]
Aeroquip Corp.	[illegible]	[illegible]	[illegible]
Allis Chalmers	[illegible]	[illegible]	[illegible]
American Chain & Cable	[illegible]	38 [illegible]	[illegible]
American Machine & Foundry	[illegible]	[illegible]	[illegible]
American Machine & Metals	[illegible]	[illegible]	[illegible]
American Optical	[illegible]	[illegible]	[illegible]
American Tel. & Tel.	[illegible]	[illegible]	[illegible]
Beckman Instruments	[illegible]	[illegible]	[illegible]
Bell & Howell	[illegible]	[illegible]	[illegible]
Bendix Aviation	[illegible]	42	[illegible]
Boeing Airplane	51 1/8	[illegible]	[illegible]
Bullard	[illegible]	[illegible]	[illegible]
Bulova Watch	[illegible]	[illegible]	[illegible]
Burroughs	52 3/8	27 7/8	[illegible]
Carborundum	[illegible]	26 1/4	[illegible]
Cincinnati Milling Machine	50 1/2	[illegible]	[illegible]
Clevite	25 1/2	15 1/8	[illegible]
Columbia Broadcasting A	[illegible]	23 1/2	[illegible]
Consolidated Electrodynamics	54 3/4	25 1/8	34
Consolidated Electronics	35 1/2	18	24 [illegible]
Cornell Dubilier	27 1/2	12 1/2	13 [illegible]
Corning Glass	100 1/4	57 1/4	[illegible]
Curtiss-Wright	47 5/8	20 5/8	23
Cutler Hammer	64 3/4	40 1/2	42
Daystrom	47	27 1/2	[illegible]
Douglas Aircraft	[illegible]	50 3/8	[illegible]
Eastman Kodak	115	91 3/4	103 7/8
Eaton Manufacturing	54 1/4	38 1/2	42 3/4
Electric Auto Lite	40 5/8	24 1/2	27 [illegible]
Elgin Watch	14 1/8	[illegible] 5/8	7 7/8
Emerson Electric	34 3/8	22 1/8	33
Food Machinery & Chemical	[illegible]	42 3/4	52 1/2
Gamewell	36 1/2	20	23 3/8
Garrett	54	[illegible] 1/4	32 1/4
General Dynamics	[illegible] 5/8	46 3/4	56 3/8
General Electric	72 3/8	52 3/8	61 3/8
General Instrument	18 1/8	4	5 3/8
General Mills	69	56	60
General Precision Equipment	[illegible]	[illegible]	[illegible]
General Railway Signal	[illegible]	[illegible]	[illegible]
General Telephone	[illegible]	[illegible]	[illegible]
General Time	[illegible]	[illegible]	[illegible]
General Tire & Rubber	[illegible]	[illegible]	[illegible]
International Bus. Machines	[illegible]	[illegible]	[illegible]
International Tel. & Tel.	[illegible]	[illegible]	[illegible]
ITE Circuit Breaker	[illegible]	[illegible]	[illegible]
Lockheed Aircraft	[illegible]	[illegible]	[illegible]
Litton Industries	[illegible]	[illegible]	[illegible]
Magnavox	[illegible]	[illegible]	[illegible]
Minneapolis Honeywell	[illegible]	[illegible]	[illegible]
Minnesota Mining & Mfg.	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
National Acme	[illegible]	[illegible]	[illegible]
National Cash Register	[illegible]	[illegible]	[illegible]
North American Aviation	[illegible]	[illegible]	[illegible]
Northrop Aircraft	[illegible]	[illegible]	[illegible]

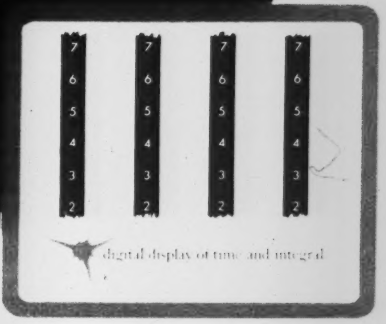
Continued on page 590

TIME AND INTEGRAL

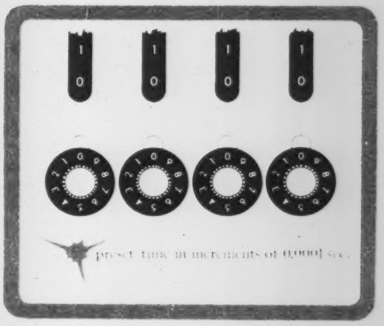
displayed instantly



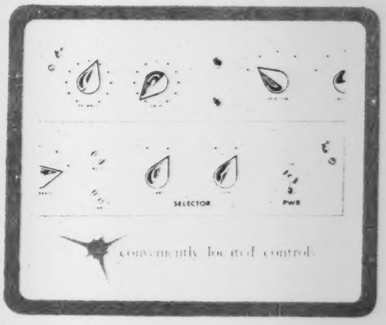
by the ALINCO model 270 Integrating System



digital display of time and integral



preset time in increments of 0.0001 sec.



conveniently located controls

THERE'S no need for planimeters or tedious arithmetic when you use the all-electronic Model 270. Designed to compute time integrals in studies of transient phenomena and in statistical quality control, the Model 270 counts at the rate of 10,000 per second. With such resolution, rapidly changing phenomena as short as 10 milliseconds in duration can be integrated to a higher degree of accuracy than heretofore possible. Convert *any* phenomenon—torque, stress, velocity, pressure, force, flow, acceleration, etc.—to a d.c. analog signal and feed it to the Model 270. Counting begins by preset signal level or by closing contacts, and stops by signal decay or by preset time (in increments of 0.0001 sec.). When the test is finished, both time and total integral are displayed on twelve digital counters. The answer often represents a ten-fold increase in accuracy over other integrating methods, and you have it *immediately*, whether your test is in the lab or out in the field. Remember, too, that ALINCO supplies a variety of high-performance instruments which can speed your projects to completion with the highest accuracies obtainable. Send for detailed literature on these guaranteed, field-proven instruments.

For more information circle **27** on Inquiry Card.

ALINCO

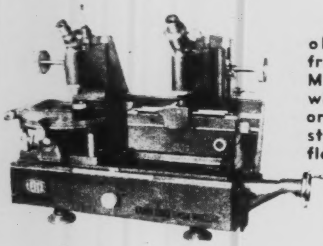
ALLEGANY INSTRUMENT CO. INC.

EASTERN DIVISION:
1091 WILLS MOUNTAIN
CUMBERLAND, MARYLAND
WESTERN DIVISION:
1052 WEST 6TH STREET
LOS ANGELES 17, CAL.

Leitz **PERFLECTOMETER**

A **NEW** CONCEPT IN INTERNAL GAGING

- FOR BORES AS SMALL AS .030" DIAMETER
- AND AS LARGE AS 8" DIAMETER



Measurements are obtained directly from a compensated Master glass scale without gage blocks or other comparative standards. The Perflectometer is particularly valuable for determining wear in ring gages, snap gages, etc.

All measurements are made without contacting the work by using a reflected target as reference point.

Request catalog 81/176

OPTO-METRIC TOOLS, INC.
1371A VARICK STREET, NEW YORK 13, N. Y.

For more information circle **28** on inquiry card

New York Stock Exchange

Continued from page 588

Otis Elevator	[illegible]	[illegible]	[illegible]
Pullman	[illegible]	41	[illegible]
Radio Corp. of America	[illegible]	[illegible]	[illegible]
Raytheon	[illegible]	[illegible]	[illegible]
Reliance Electric	[illegible]	[illegible]	[illegible]
Rheem Manufacturing	[illegible]	[illegible]	[illegible]
Robertshaw Fulton	[illegible]	[illegible]	[illegible]
Royal-McBee	[illegible]	[illegible]	[illegible]
Sangamo Electric	[illegible]	[illegible]	[illegible]
Sperry Rand	[illegible]	[illegible]	[illegible]
Square D	[illegible]	[illegible]	[illegible]
Standard Coil Products	[illegible]	[illegible]	[illegible]
Starrett (L.S.)	[illegible]	[illegible]	[illegible]
Stewart-Warner	[illegible]	[illegible]	[illegible]
Sylvania Electric	[illegible]	[illegible]	[illegible]
TelAutograph	[illegible]	[illegible]	[illegible]
Texas Instruments	[illegible]	[illegible]	[illegible]
Thompson Products	[illegible]	[illegible]	[illegible]
Tung-Sol Electric	[illegible]	[illegible]	[illegible]
Underwood Corp.	[illegible]	[illegible]	[illegible]
Union Carbide & Carbon	[illegible]	[illegible]	[illegible]
United Shoe Machinery	[illegible]	[illegible]	[illegible]
Western Union	[illegible]	[illegible]	[illegible]
Westinghouse Air Brake	[illegible]	[illegible]	[illegible]
Westinghouse Electric	[illegible]	[illegible]	[illegible]
Worthington Corp.	[illegible]	[illegible]	[illegible]

1) Not Traded - Bid, Asked
2)
3) [illegible]

Over-The-Counter

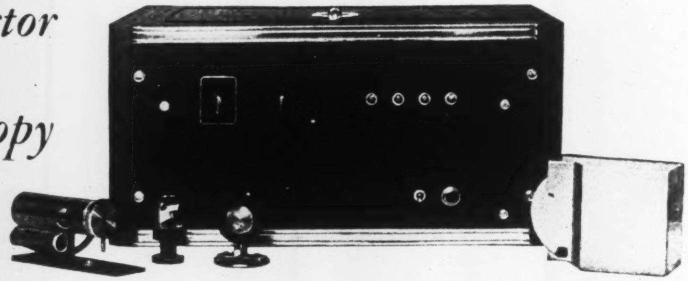
OVER-THE-COUNTER

Quotation As of March 17/58

	Bid	Asked
Aerovox Corp.	4 1/8	4 5/8
Aircraft Radio Corp.	17 1/2	18 3/4
Argus Corp.	17 1/4	18
Eitel-McCullough Co.	20 1/2	21 1/2
Electronics Associates	37	38 1/2
Erie Resistor Corp.	6	6 3/8
G.M Giannini	14 3/8	15 1/2
Liquidometer Corp.	5 1/2	6 1/4
W.L. Maxson	5 1/4	5 3/4
Penn Controls, Inc	14 3/4	16
Speer Carbon, Inc	24	25
Sprague Electric	31 1/2	32 1/4
Taylor Instrument	30	31
Telecomputing Corp.	4 1/4	4 1/2
Topp Industries	9	9 5/8
Varian Associates	15	15 1/2
Vitro Corp. of America	17 7/8	18 3/8

A Superior Detector
for
Infra-Red Spectroscopy

GOLAY PNEUMATIC DETECTOR



Among the characteristics that render the Golay Detector superior to other types of detectors for use in infrared spectroscopy are:

1. **An effective sensitive area 3/32" in diameter.**
2. **Sensitivity of 6 x 10^{-11} watts RMSENI when used with "chopped beam" method and with recording time constant of 1.6 second.**
3. **Uniform sensitivity from the ultra-violet through the visible and the entire infra-red, and up to the micro-wave region.**
4. **Improved, drift-free, A.C. operated amplifier with step gain controls and four response periods.**

Write for EPLAB Bulletin
No. 10

THE EPPLEY LABORATORY, INC.
SCIENTIFIC INSTRUMENTS
2 SHEFFIELD AVENUE, NEWPORT, RHODE ISLAND, U.S.A.

For more information circle **29** on inquiry card

FOXBORO BREAKS "RANGE BARRIER" IN SMALL-FLOW TRANSMISSION

FOXBORO
IN OUT
FOXBORO
INTEGRAL ORIFICE
31655
15-30 PSI

Flows as small as .003 gpm accurately measured, with new Integral Orifice d/p Cell* Transmitter

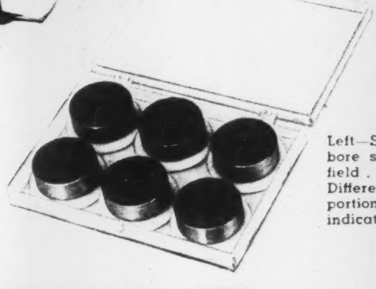
Now you can measure and transmit small flows with full accuracy and dependability! The new Integral Orifice d/p Cell Transmitter easily handles exceedingly low flow rates formerly impossible in pilot plant operations, research problems, and fluid ratioing.

Installed directly in the process line, the Foxboro Integral Orifice d/p Cell Transmitter needs no meter primary device or connection-piping . . . and no straight runs. It can be installed in any position. A direct 3-15 psi output signal is delivered to any standard indicator or recorder.

By suitable range selection through change of orifice inserts, flow rates as low as 0.003 gpm or as high as 8.3 gpm can be accurately measured.

The Foxboro Type 13A Integral Orifice Transmitter gives you, not only new high accuracy in measurement, but also accurate remote indicating and recording. Write for complete details. **The Foxboro Company, 144 Norfolk St., Foxboro, Mass., U.S.A.**

**Reg. U.S. Pat. Off.*



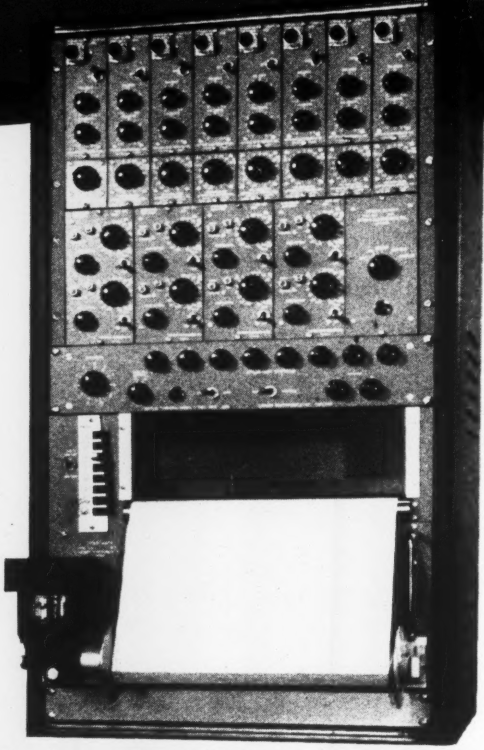
Left—Set of six interchangeable orifices is available in standard bore sizes from 0.020" to 0.250". They're easily changed in the field . . . merely inserted within the transmitter connection block. Differential pressure across orifice is converted to directly proportional 3-15 psi air output signal and transmitted to remote indicator or recorder.

FOXBORO INTEGRAL ORIFICE d/p cell transmitter

For more information circle **30** on inquiry card.

[illegible] ALL TRANSISTOR
TYPE R DYNOGRAPH

the most versatile...most sensitive direct writing unit available

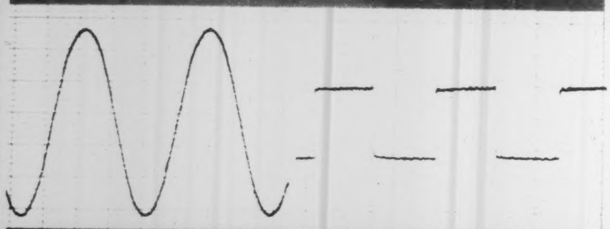


Combining all these features...

- ☆ stable d-c sensitivity of one microvolt per mm
- ☆ true differential input
- ☆ high input impedance
- ☆ response to beyond 150 cps.
- ☆ reluctance, differential transformer, strain gage with a-c or d-c excitation, thermocouples, etc., used with all amplifiers
- ☆ deflection time less than 2 milliseconds
- ☆ fixed precision calibration
- ☆ instant warm-up
- ☆ precision source for d-c and 400 cycle excitation, self-contained
- ☆ zero suppression, twenty times full scale, both directions

all these features...plus 8 channels in only 33¼″ of rack space

FULL SCALE, UNRETOUCHED CHARTS PRODUCED ON THE TYPE R DYNOGRAPH



EXTREME SENSITIVITY—

10 Microvolt RMS Sine Wave [illegible]

Ten Microvolt D-C Square Wave

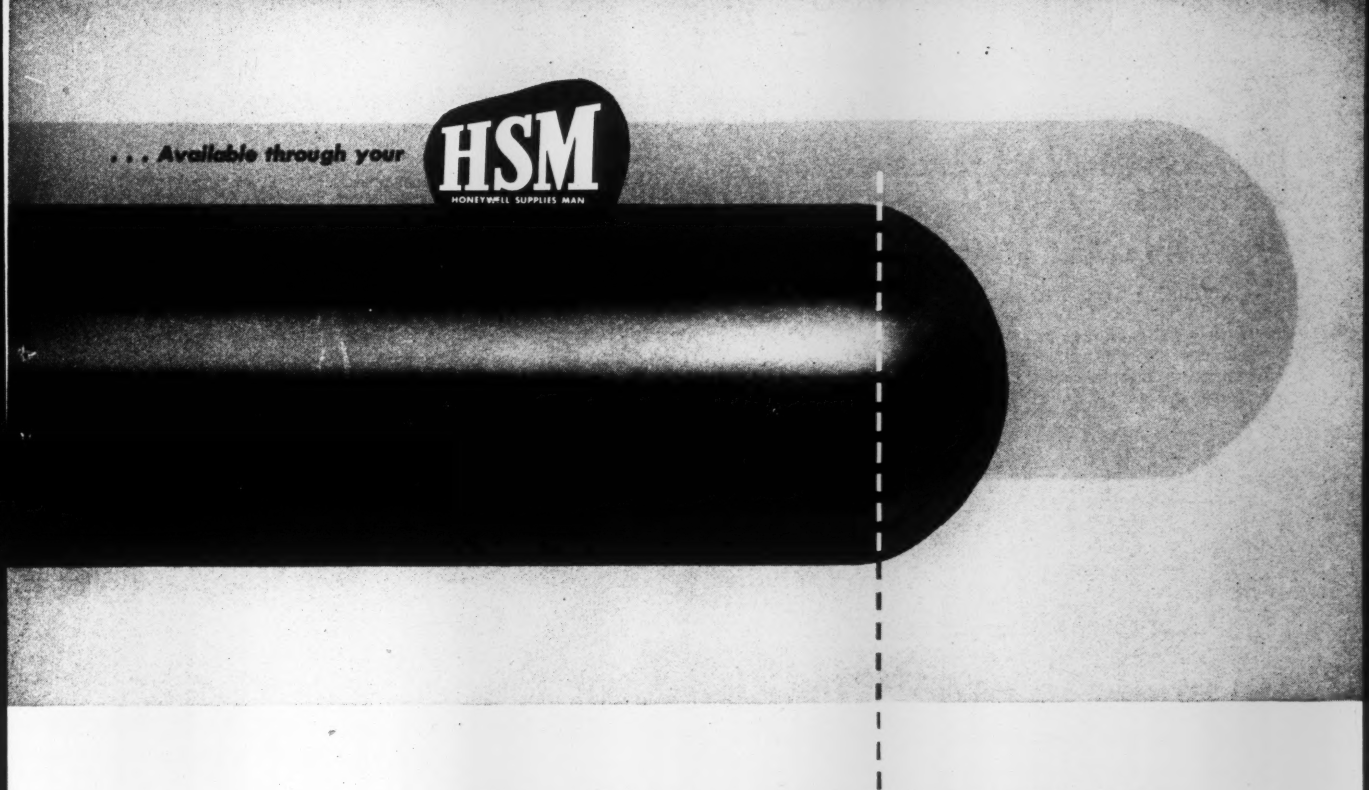
Pen [illegible], ink, heat or electric rectilinear [illegible] electric curvilinear. Readily convertible.

Whatever your application for direct writing recorders . . . you should investigate the ability of the Offner Type R Dynograph to do the job *better* and more *simply*. Using transistor circuits* developed and tested for over two years in hundreds of channels of Offner medical equipment, the Type R Dynograph is, we believe, superior in practically every respect to *any other* direct writing oscillograph. Write on your company letterhead for literature giving details and specifications.

*Patents granted and pending

OFFNER ELECTRONICS INC.
5326 N. Kedzie Ave., Chicago 25, U.S.A.

For more information circle 31 on inquiry card.



SPUN-END
Protecting Tubes
for long, reliable thermocouple service

Spun-end construction adds extra quality to Honeywell closed-end drawn metal protecting tubes . . . at no increase in price.

These tubes keep thermocouple wires safe from corrosion and mechanical damage. They're made to withstand the toughest abuse you'll give them on the job.

Available in carbon steel, seamless steel, stainless steel, *Inconel**, *Resisteat***, nickel and wrought iron.

Order from your Honeywell Supplies Man. He can give you valuable assistance with your process control problems, as well as help you select pyrometer supplies. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

**Inconel is a trade name of the International Nickel Company.*
***Resisteat is a trade name of Minneapolis-Honeywell Regulator Co.*

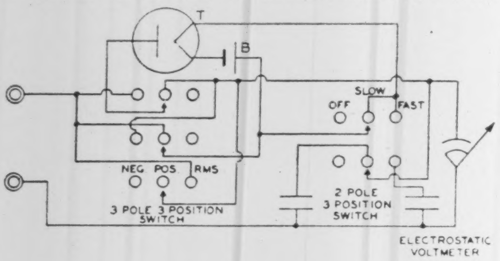
Honeywell

H HONEYWELL First in Controls

briefs

Measurement of Peak Voltages

In computing flux density, it is advantageous to use average values instead of RMS because the flux density is directly proportional to the average value of the wave. Hence the use of an average reading voltmeter will save an appreciable amount of calculation. If the measurements are to be used for certain specialized applications it is most desirable to obtain the peak (crest) value of the wave. Voltage breakdown, corona, human susceptance to shock, certain comparison circuits, and many other things tend to follow the peak or crest value rather than either the RMS or average value.—(*From new 4-page company publication "Electrical Measurements," Dec. 1957, Sensitive Research Instrument Corp., New Rochelle, N. Y.*)

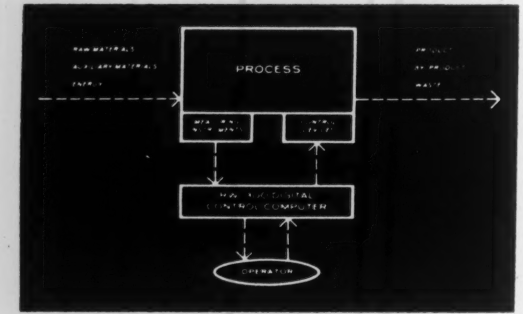


For this literature circle **150** on inquiry card.

Digital Control Computer

The RW-300 brings a new degree of automatic control and efficiency to continuous and batch process such as those employed in the petroleum refining, petrochemical, chemical, metals, glass, food, and paper industries.

With an RW-300 digital control system, as shown in the block diagram, the measuring devices send signals directly to the computer where the input conversion equipment converts the signals into digital form. The computer next interprets the input data, carrying out any scaling, linearizing, or compensating calculations that are necessary. It then proceeds to the principal control calculations, which include equation solving, interpolation, integration maximizing and minimizing, averaging, correlating, and smoothing. The results, changed to analog form in the output conversion equipment, actuate plant controllers to make the appropriate changes in the process.—(*From new 4-page Bulletin "RW-300 Digital Control Computer," Ramo-Wooldridge Corp., 5730 Arbor Vitae St., Los Angeles 45, Calif.*)

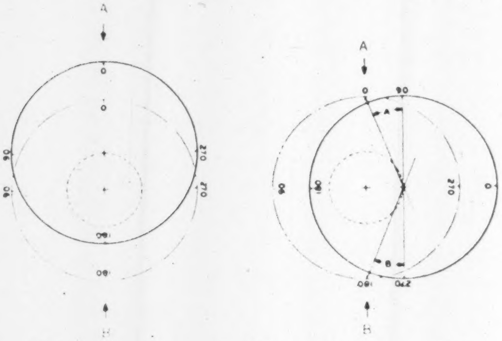


For this literature circle **151** on inquiry card.

Unisec Coincidence Reading System

"Unisec" is a high-precision angular measuring device (highest possible outside of an optical reading theodolite; reads directly to one second) which may be attached to a shaft of any rotatable device, where highly precise positioning is desirable.

For many years it has been recognized that "if two sides of a circle are read, eccentric errors are eliminated."

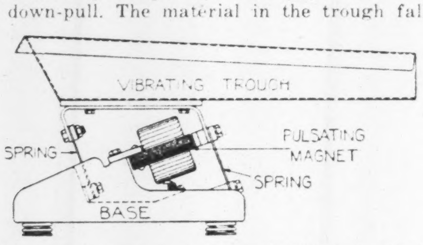


If a perfect circle is rotated in an eccentric manner, the path of the true center of the circle would be as indicated by the dotted circle in the Fig. It is obvious that one index gives an erroneous reading, except in one position of the circle. If this eccentrically mounted circle is rotated through a true 90° angle, it would appear as in second Fig. Index A would indicate that the angle of rotation was greater than 90° by the amount of angle "A", and Index B would indicate that the angle was less than 90° by the amount of angle "B". Using the principle of reading both sides of a circle at once, all eccentric errors are removed. The circle itself is graduated in intervals of 10 minutes of arc, and therefore contains 2,160 graduations. These 10 minute intervals are sub-divided by a micrometer scale which is attached to a deviating prism. The scale is divided into 300 equal parts or the equivalent of 5 minutes of arc.—(*From new 8-page brochure, W. & L. E. Gurley, Industrial Div., 514 Fulton St., Troy, N. Y.*)

For this literature circle **152** on inquiry card.

Vibratory Feeders

A trough, mounted on flexible leaf springs, is vibrated at a high speed by an electromagnet. The magnet, energized by pulsating current, pulls the trough sharply down and back—then the leaf springs return it up and forward to its original position—although not so sharply as the down-pull. The material in the trough falls perpendicularly, as the trough is pulled sharply backwards out from under it, to a new position forward in the trough pan—then as the leaf springs return it up and forward, the material is carried with it—to have the same action repeated—at high speed.

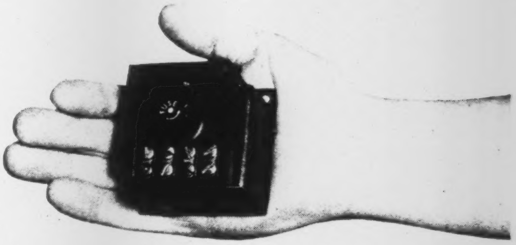


This trough action—differential reciprocation or vibration as it is commonly called—makes the material appear to flow like water.—(*From new 32-page bulletin, Syntron Company, 702 Lexington Ave., Homer City, Pa.*)

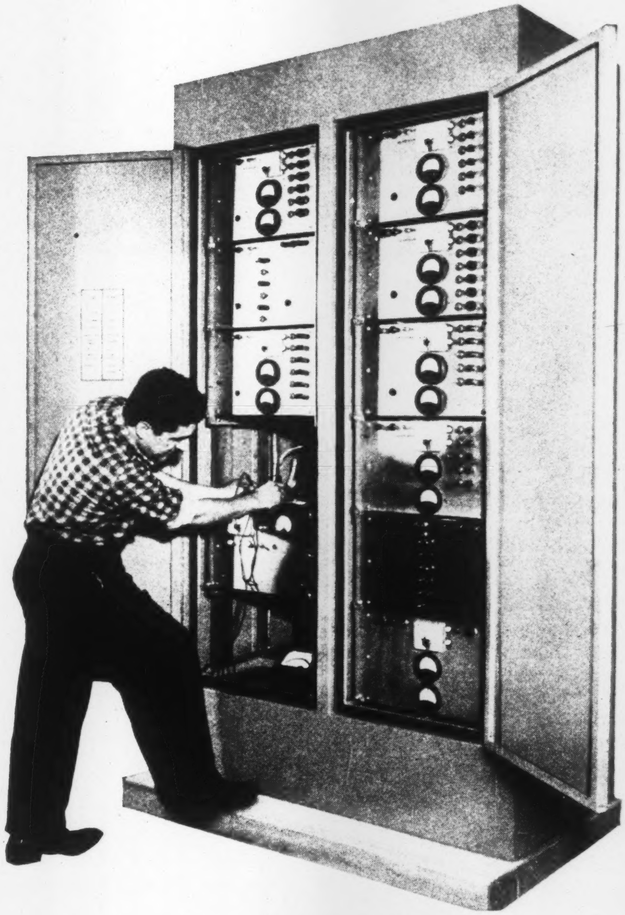
For this literature circle **153** on inquiry card.

Save design time, avoid assembly headaches with General Electric custom-designed DC power supplies

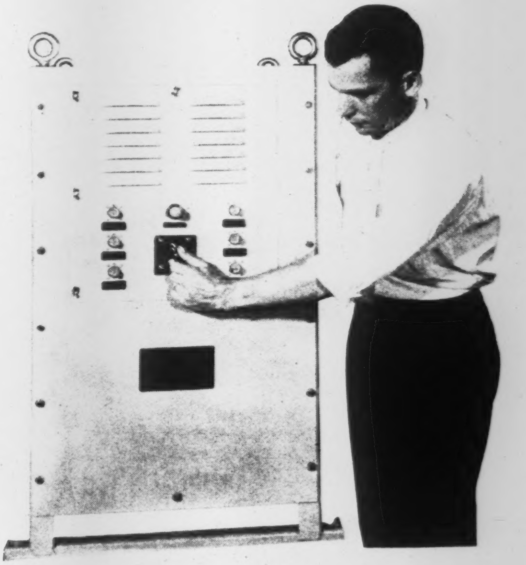
NO PROBLEM TOO GREAT . . . **. . . NO PROBLEM TOO SMALL!**



Individual packages



Complete systems



Partial systems

Subcontract your power supply problems to General Electric! Whether your requirements can be met by the existing, completely engineered supplies we have on hand—or involve custom-packaging of "building blocks"—or call for altogether new designs—give us the power supply *system* responsibility! Consult your local Apparatus Sales Office, or write for bulletin GEA-6690 to Section B465-5, General Electric Co., Rectifier Dept., Lynchburg, Va.

Progress Is Our Most Important Product

GENERAL ELECTRIC

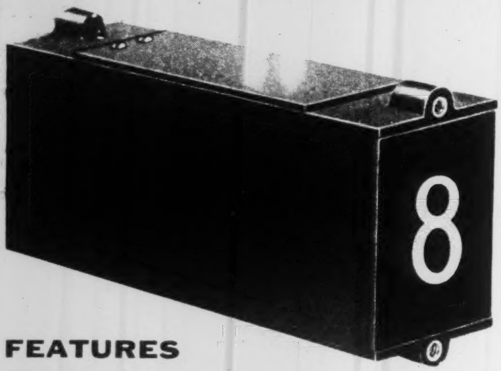
For more information circle **32** on inquiry card.

new...improved

IN-LINE

DIGITAL DISPLAY

with One-Plane Presentation



FEATURES

- Recently developed high-contrast viewing screen for utmost visual sharpness!
- Digit style of your choice!
- Colored digits of your choice! Suitable to environmental ambient room light.
- Digital presentation complementing manufacturer's original equipment!

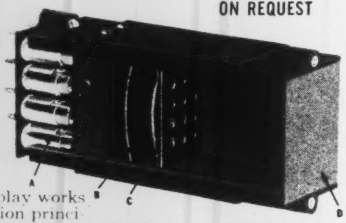
Here's a new type of In-Line Digital Display. All numbers and or characters appear on the front surface of the unit, and are of uniform size and intensity. In addition to being faster and easier to read, the numbers may be quickly seen from any angle of viewing.

The In-Line Display is available as a single unit, or in assembled groups of two, three, four, etc., ready for panel mounting. The viewing screen extends the full width of the individual unit so that final assembly presents a continuous surface for fast, easy reading.

PRICE PER UNIT $15^50

QUANTITY PRICES ON REQUEST

HOW THE EIE IN-LINE DIGITAL DISPLAY OPERATES



The In-Line Display works on a rear-projection principle. When the lamp (A) at rear of the unit is lighted, it projects the corresponding character on the condensing lens (B) through a projection lens (C) onto the viewing screen (D) at the front of the unit.

WRITE TODAY FOR COMPLETE DETAILED SPECIFICATIONS

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EIE INDUSTRIAL ELECTRONIC ENGINEERS

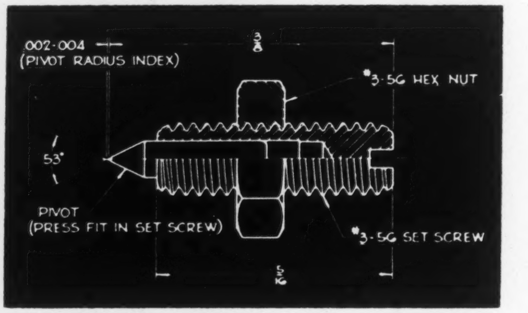
Engineers and Manufacturers of Fully Automatic Systems and Machines

3973 Lankershim Blvd., North Hollywood, Calif.

For more information circle 33 on inquiry card.

Instrument Pivots

A line of standardized alloy steel pivots has been worked out that should prove acceptable for the vast majority of applications and are the most economical and practical sizes to use. These standard pivots have a diameter of 0.020", a cone angle of 50°, lengths of 0.075" and 0.100", respectively, and three pivot point curvatures for each of the above lengths.



A pivot/set screw/nut assembly may be used in conjunction with a jewel, a coined vee or in a chamfered hole in a shaft.—*(From new Bulletins D-19 and* 102, *Welton V. Johnson Engineering Co., Inc.,* 95 *Summit Ave., Summit, N. J.)*

For more information circle **154** on inquiry card.

Industrial Nuclear Radiation

Rapidly nearing completion is the large Nucledyne hot cell which is required for the study of the effects of high gamma radiation on materials, as well as electrical components and systems in air . . . The cell will house a 62,000 curie Cobalt 60 source which will be stored in a 22-foot well capped with deionized water. During irradiation periods, an elevator raises the source of the cell level in 30 seconds. A complete electrical personnel safety interlocking system is provided.—*(From new* 18-*page brochure "Projects," Nucledyne Corp.,* 8100 *Monticello Ave., Skokie, Ill.)*

For more information circle **155** on inquiry card.

Instrument Rectifiers

The five full-wave conventional circuits are shown as Figs. 1 through 5. The efficiency factor shown in connection with each circuit is an indication of the sensitivity of the a. c. ranges in ohms per volt. It is on this basis that the values of the multiplier resistors in the instrument were determined in the design of the instrument. On this point alone, the necessity for replacing the rectifier with the proper type is obvious.—*(From new* 40-*page "Instrument Rectifier Replacement Guide" which includes lists of manufacturers using maker's equipment, Conant Labs.,* 6500 *O St., Lincoln* 5, *Nebraska)*

FULL WAVE CIRCUITS

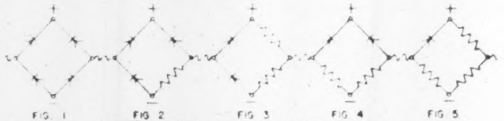
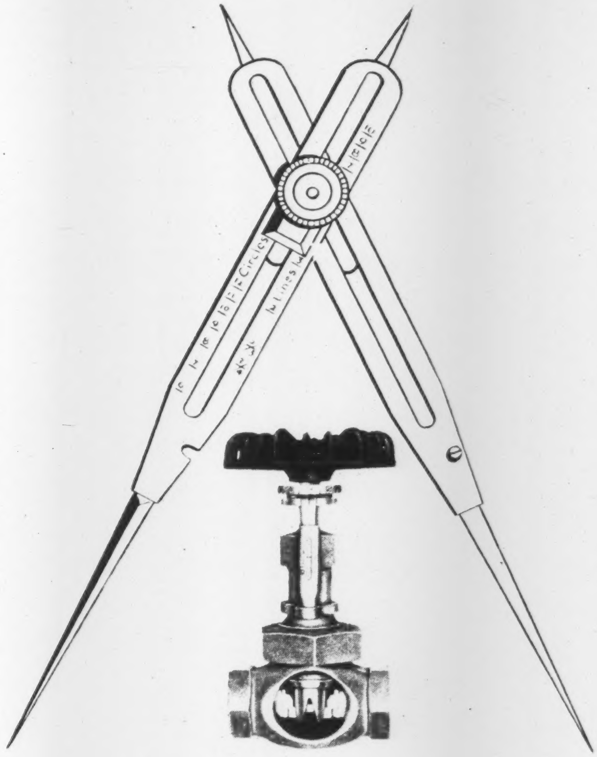


FIG. 1 BRIDGE FACTOR 9 | FIG 2 THREE QUARTER BRIDGE FACTOR 84 | FIG 3 SERIES HALF BRIDGE FACTOR 44 | FIG 4 OPPOSED HALF BRIDGE FACTOR 72 | FIG 5 QUARTER BRIDGE FACTOR 36

For more information circle **156** on inquiry card.



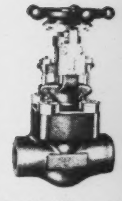
PROPORTIONER

controls flow to save for you

The V-port disc in all Hancock "Flocontrol" Valves insures proportional flow throughout the entire lift of the stem. They are valves that help you achieve uniform product quality through closer control, save steam and fuel on process work, and cut maintenance costs.

"3 in 1" valve design combines variable orifice with shut-off and micrometer dial and pointer. The valve opening can be set within 1/10 turn of the handwheel—you can duplicate all settings easily, instantly. No shut-off valve required—flow is in a straight line, with separate shut-off seating surface located away from the V-ports.

Hancock "Flocontrol" Valves are available in Bronze and Steel to meet the most demanding services. Ask your industrial supply distributor for details.



Hancock "Flocontrol" valves assure positive pinpoint control—eliminate all guesswork.

HANCOCK "FLOCONTROL" VALVES

A product of

MANNING, MAXWELL & MOORE, INC.

Consolidated Ashcroft Hancock Division • Watertown, Massachusetts
In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

HI-58

For more information circle **34** on inquiry card.

ALL NEW!

Veeder-Root
Panel-Mounted High Speed
Electrical Counters

...with electric resetting in 1/10th of a second

These new Series 1591 Electrical Counters fill the gap between standard and electronic counters for industrial, data processing, or laboratory and scientific uses. They're designed for accuracy and long life at very high speeds (rated at 3000 counts per minute, with extended test-runs up to 6000 cpm).

And they have the unmatched convenience of *instant push-button resetting*, either mechanically right on the machine . . . or electrically from a distance. Panel-groups of these counters can be placed right in your office . . . *and one button can reset an entire panel.* Counters feature large figures, small size, low-wattage coils for continuous duty and other V-R vantage points on which patents are pending.

These new and different counters are the latest evidence that Veeder-Root design and development always keep pace with modern counting requirements. Write for specifications and prices.

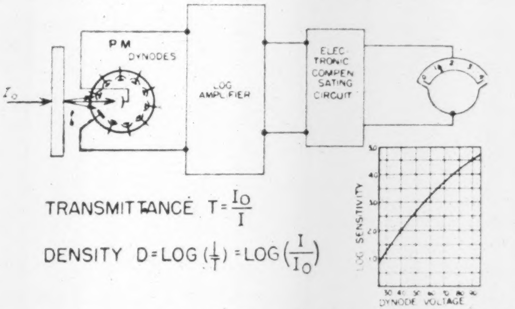
Added Evidence
that Everyone
Can Count on

VEEDER-ROOT
INCORPORATED
HARTFORD 2, CONNECTICUT
Hartford, Conn. • Greenville, S. C. • Altoona, Pa. • Chicago
New York • Los Angeles • San Francisco • Montreal
Offices and Agents in Principal Cities

For more information circle 35 on inquiry card

Dynode Feedback Circuit

The basic operating principle of the photomultiplier dynode feedback circuit is relatively simple. When a given specimen density is inserted in the light beam the photomultiplier tube output current is at first reduced. A voltmeter which responds to the dynode voltage applied to the tube necessary to restore the loss of output current for a given density specimen can be calibrated in terms of an optical density scale. The relationship between log sensitivity of the photomultiplier tube and dynode voltage is shown in the graph and is virtually logarithmic.



TRANSMITTANCE $T = \frac{I_0}{I}$

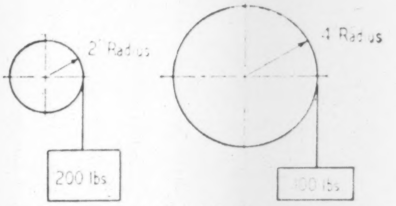
DENSITY $D = LOG\left(\frac{1}{T}\right) = LOG\left(\frac{I}{I_0}\right)$

Applications (include): Brightness and opacity measurement of paper; paper chromatography; electrophoresis; transmission density measurements of glass and other transparent films; measurement of thickness of coatings, including metallic, by transmitted light; transmission density measurements of tissue stains in the medical field.—*(From new 8-page bulletin on Macbeth-Ansco Model 12-A, Macbeth Instrument Corp., Dept. P. 10, P.O. Box 950, Newburgh, N. Y.)*

For this literature circle **157** on inquiry card

Speed Reducers

When selecting a Speed Reducer for your particular application there are three main factors to take into consideration. They are Ratio, Horsepower and Torque.



The ratio is the relationship between the speed of the driving mechanism and the speed required at the output shaft of the unit. Thus if we have a motor at 1750 RPM and an output speed required of 50 RPM:

$$\text{RATIO} = \frac{\text{Speed of Driver}}{\text{Required Output Speed}} = \frac{1750}{50} = 35 \text{ to } 1$$

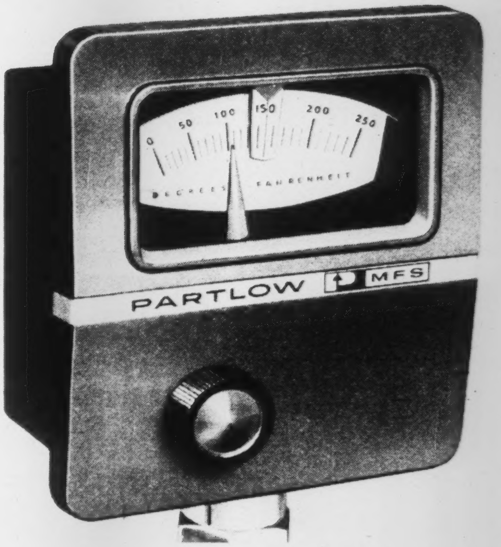
Torque and Horsepower Relationship:
Torque = Load × Radius = L × R

$$\text{H.P.} = \frac{\text{Load} \times \text{Feet per Minute}}{33{,}000}$$

$$\text{H.P.} = \frac{\text{Torque} \times \text{RPM}}{63{,}025}$$

(From new 176-page Catalog 80, Grant Gear Works Inc., 154 W. Second St., Boston 27, Mass.)

For this literature circle **158** on inquiry card



Designed with the Look of Tomorrow
by Raymond Loewy Associates

NEW PARTLOW
MFS TEMPERATURE CONTROL

New Looks, Convenience, Efficiency
for Your Process Equipment

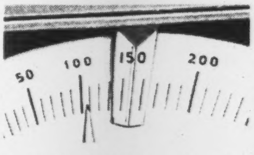
Striking as they are, good looks are only part of the story of Partlow's spectacular new control. Inside and out, the MFS is as rugged and efficient as a temperature control can be, its tough mercury-actuated element having been built to retain sensitivity and accuracy even under extreme conditions. Convenient, too! You can interchange the mercury element right out in the field . . . no factory adjustment is required.

The MFS comes in 10 scale ranges. Accurate within ½ of 1% of scale range, it is especially adaptable to control applications where temperature variations must be kept at a minimum; or where sudden temperature changes demand instant response.

If your product or process requires close, positive temperature control within the −30° F. to 1100° F. range, you are invited to test this advanced new instrument soon. Write, wire or phone today.

THE PARTLOW CORP.
Dept. IA-458, New Hartford, N. Y.

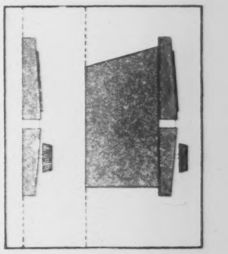
Only in the Partlow MFS so many important innovations:



ACCU-VISION DIAL — Magnified pointer for closest settings. Dial calibrations, pointers and background scientifically color-contrasted for easy readability—even at a distance.

LOOK TO PARTLOW FOR:

Recording Controls
Indicating Controls
Non-indicating Electrical Controls
Non-indicating Mechanical Controls
Recording and Indicating Thermometers
Combustion Safeguards
Timers
Limit Controls



FLUSH OR WALL MOUNTING — No additional brackets or hardware are required. Case is grey reinforced plastic — tough, lightweight, easy to clean, won't crack under extreme temperatures.

PARTLOW

For more information circle **36** on inquiry card.

THE RW-300

is the first digital computer for automatic process control and data logging

The Ramo-Wooldridge RW-300 Digital Control Computer is available *now* to control process units in oil refineries, chemical plants, and other process industries.

The new RW-300 offers outstanding opportunities for higher profits from existing and future plants—through reduced operating costs, increased throughput and yields, and improved product quality. These benefits will pay back an investment in an RW-300 digital control system within six months to two years.

For technical information on automatic process control and advanced data logging with the RW-300, write: Director of Marketing, The Thompson-Ramo-Wooldridge Products Company, P.O. Box 45067, Airport Station, Los Angeles 45, California, or call OSborne 5-4601.

See the RW-300 in operation at the ACS exhibition, April 13-17, San Francisco.

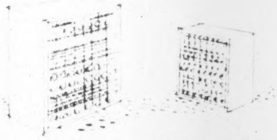
THE THOMPSON-RAMO-WOOLDRIDGE PRODUCTS COMPANY

For more information circle **37** on inquiry card.

High-Speed Analog Computers, Key to Rapid System Development

Q: What are the advantages of high-speed (compressed-time) analog computation over real-time analog computation?

A: The principal advantage of the high-speed analog computer is that the problem is solved repetitively at a rapid rate, ranging from 10 to 60 complete solutions per second . . . This is about 3000 times faster than real time. The operator can essentially make continuous changes in the problem parameters and watch the changing solution



REAL TIME vs. HIGH SPEED

. . . This operating method makes the high-speed analog computer extremely useful in any problem which requires solution by repeated trials. Since repeated trials, using different sets of problem and system parameters, can be made very rapidly, it is easy to converge upon the desired solution. Control system design, for example, usually requires solution by repeated trials.

Q: What are the relative physical sizes and power demands of high-speed versus real-time analog computers?

A: The high-speed analog computer is smaller and requires less power than the real-time analog computer.—*(From new 8-page brochure "High Speed Analog Computers, Key to Rapid System Development," GPS Instrument Company, Inc., 811 Boylston St., Boston 16, Mass.)*

For this literature circle **159** on inquiry card.

Safety-Relief Valves Pilot Operated

The AGCO Type 2 Pilot Operated Valve operates with a floating piston of differential area design. Full line size orifices are standard in all sizes. Features of the valve include full capacity with no overpressure or accumulation, replaceable teflon seats in both pilot and main valve, manual blowdown provision, and extreme ease of maintenance. Gas or vapor service only.—*(From new 4-page Composite Brochure, Anderson, Greenwood & Co., 1400 N. Rice, Bellaire, Texas.)*

For this literature circle **160** on inquiry card.

Precision Projecting Microscope

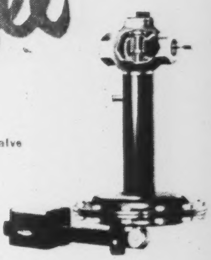
The specimen to be tested is projected into a glass screen of 180 mm diameter and can be examined in the following ways: (1) *diascopy* (transmitted light), (2) *episcopy* (surface light) to obtain maximum relief, (3) *dia-episcopy* (transmitted light combined with surface light) to examine the surface as well as the outlines . . . "Projectina" can simultaneously be used as a microscope and the test piece can be examined on the screen as well as in the eye-piece. The fixed illuminations allow an easy microscopy and projection in transmitted bright and dark-field as well as surface bright and dark-field.

A simple polarizing equipment is available which can be used for microscopy and projection, transmitted and surface light, micro and macro photography. *(From new 8-page catalog, Projectina, Switzerland, Agents: Alfred Hofmann & Co., 629 59th St., West New York, N. J.)*

For this literature circle **161** on inquiry card.

If you need to reduce fluid pressure safely, economically... call for a valve from

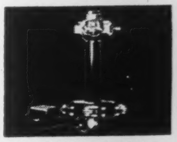
Klipfel

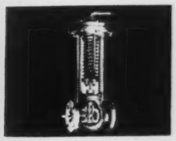

No. 310 Reducing Valve

Klipfel makes Reducing Valves for every purpose 60 different types of them, in fact. They operate on air, gas, steam, water or other liquid, with initial pressures up to 300 psi and reduced pressures as low as vacuum. You can choose from five different inner valves, three different actuating means and four loading means.

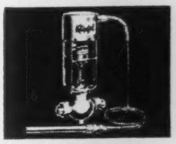
Also available from Klipfel are Float Valves, Relief Valves and Temperature Regulator Valves and special valves made of corrosion-resistant materials. For information on any valve, call your supply house or write for Catalog 54.

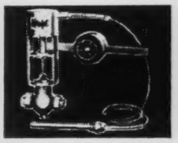
Call your supply house, or write for Catalog 54.

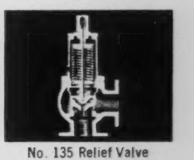

No. 410 Reducing Valve

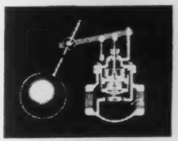

No. 300 Reducing Valve

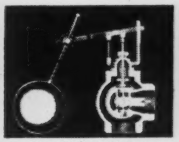
AIR MAIL
Most items shipped within 24 hours after order is received

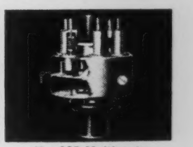

No. K-449 Temperature Regulator Valve


No. K-348 Temperature Regulator Valve


No. 135 Relief Valve


No. 7 Float Valve


No. 27 Float Valve


No. 135 Multiport Relief Valve

HAMILTON • OHIO **Klipfel** VALVES INC.

Automatic Temperature-and-Pressure-Regulating Valves Since 1902

Float Valves • Temperature Regulators • Back Pressure Valves • Reducing Valves

A DIVISION OF THE HAMILTON-THOMAS CORPORATION

For more information circle **38** on inquiry card.

INSTRUMENTS AND AUTOMATION

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- ★ FIRST IN QUALITY
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IN THE

INSTRUMENTS

and

AUTOMATION

FIELD —

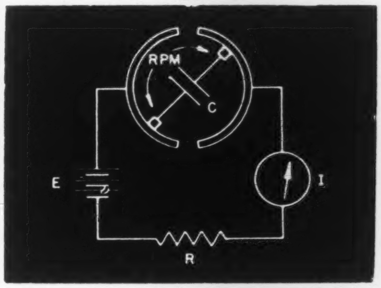
MAIL

TODAY!

Tachometers

All Metron Tachometers employ one ramification or another of the basic circuit shown in Figure 1, which is schematic only. In this sketch, the circuit is supplied with a constant voltage E connected in series with a milliameter I having resistance R and a capacitor C. The polarity of the capacitor is reversed by a commutator twice each revolution with a frequency proportional to the speed in RPM being measured. Actually, in practice, neither a rotating capacitor nor a commutator are used but are shown thus for the sake of clarity . . . Thus, the relationship of average current or reading is proportional to speed being measured. This relationship is expressed by the equation

$$I = \frac{C \times E \times RPM}{15}$$



For all practical purposes, the above equation is exact and brings to light several things: 1. Current is truly proportional to speed . . . 4. The equation does not contain the factor R which means that current values are unaffected by resistance of the circuit. 5. Current I is also dependent on the value of voltage E and the capacitor C . . . From the foregoing, it is seen that the Metron system of speed measurement is in no sense a generator type of instrument. For this reason, it is not possible to interchange Metron Indicators or Heads with indicators or generators of other makes of tachometers . . . *(From new 58-page ring binder "Tachometer Speed Changers, Comparator Gages," Metron Instrument Co., 432 Lincoln St., Denver 3, Colo.)*

For this literature circle **162** on inquiry card.

Alloyed Junction Transistors

The General Transistor germanium P-N-P and N-P-N alloyed junction transistors . . . are especially useful in broadcast receivers, wide-band video, and a variety of R.F. and I.F. applications . . . series offers a selection of alpha cutoff frequencies from which the engineer may choose, depending upon the frequency requirements of the equipment to be operated . . .

TYPICAL CHARACTERISTICS

		GT 81	GT 81HS	GT 109	GT 759R	GT 760R	GT 761R
SMALL SIGNAL CURRENT GAIN common emitter		75	100	100	25	40	70
POWER GAIN	Freq = 1000cps	42	44	44	—	—	—
	Freq = 455 KC	—	—	—	24	28	32
COLLECTOR CAPACITY Freq = 1 MC		—	—	—	16	16	14
ALPHA CUTOFF FREQUENCY		—	—	—	2.5	5	11
COLLECTOR CUTOFF CURRENT V_c = 10 V		6	6	6	6	6	6
D.C. CURRENT GAIN common emitter		—	—	—	—	—	—

Features: Hermetically sealed in metal case with glass headers. Flexible leads may be soldered directly into the circuit or used with standard plug-in sockets. Can be mounted in any position. Highly resistant to shock, vibration and extreme atmospheric conditions . . . *(From new 6-page Application Brochure G-120, General Transistor Corp., 91-27 138th Place, Jamaica 35, N. Y.)*

For this literature circle **163** on inquiry card.

INSTRUMENT ENGINEERS . . .

control small flows

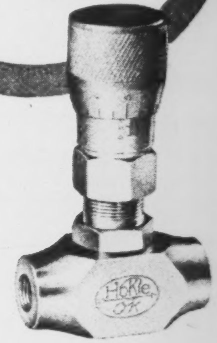
with finger tip accuracy

on

Aircraft and Automotive Test Stands
Hydraulic Equipment
Pneumatic Equipment
Gas Analyzers
Metering and Proportioning Equipment
Pilot Plants
Test Instruments

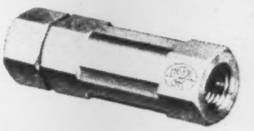
280 SERIES METERING VALVES

Two orifice sizes of 1/16" and 1/8" are available with flow controlled by an 8-degree needle point taking 20 turns to move from open to closed position. In brass with O-ring stem seal or in 316 stainless with Teflon packing. For service to 3,000 psi, operating temperatures from −60° to 450° F. All valves have panel mounting lock nut.



Vernier Modifications

Hoke's #280-25 micrometer hand-wheel kit (illustrated) helps you establish a reference point as to the number of turns required for any flow rate. A low-cost, high-value accessory for precision control.



Why buy big when you can buy small

A SPECK OF DUST

in metered fluid is all it takes to change the orifice setting in Hoke's highly-sensitive 280 Series valve. For critical metering requirements, it's always wise to use this 540 Series Micron Filter to keep foreign matter away from the valve. Complete information on request.

Hoke's Catalog MV 957 has all necessary information on 280 Series Valves and 540 Series Micron Filters. Yours for the asking.

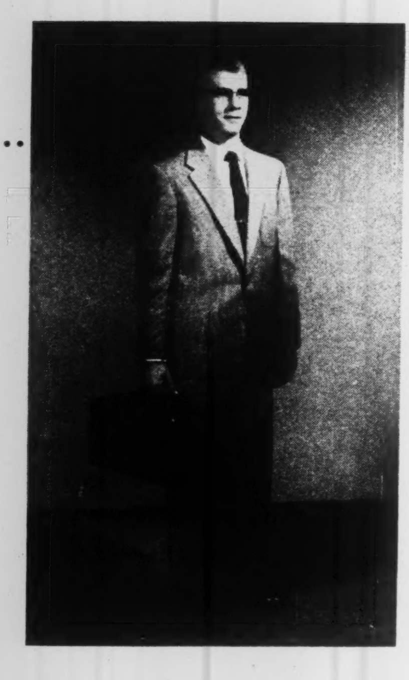
HOKE

HOKE INCORPORATED
FLUID CONTROL SPECIALISTS
231 South Dean Street
Englewood, New Jersey

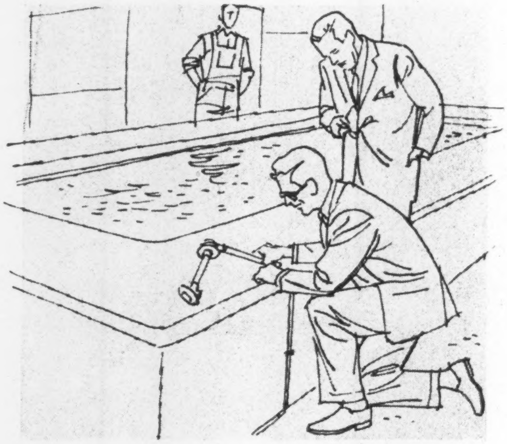
For more information circle **39** on inquiry card.

Here's the kind of service you get . . .

with HONEYWELL instrumentation



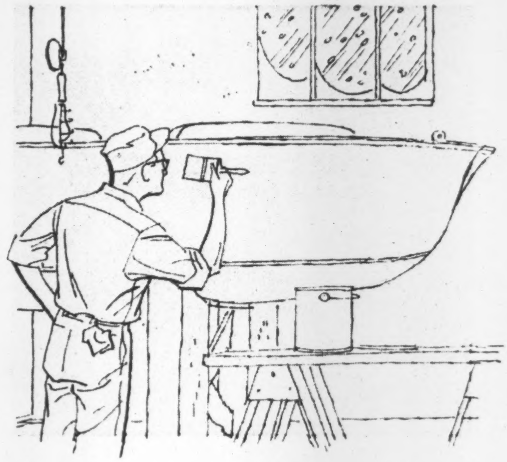
Bill Lewis, typical service engineer, proves how you can depend on Honeywell for fast, on-the-spot service even in emergencies.



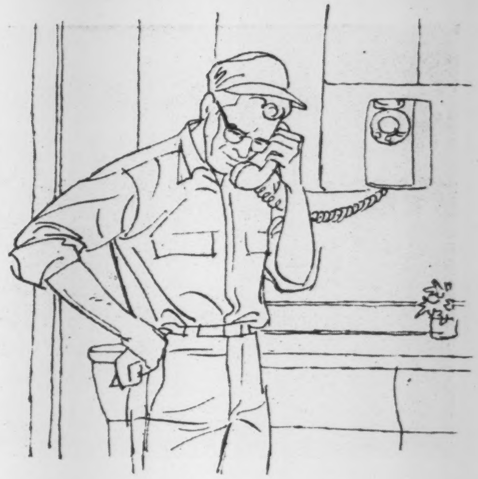
3 It took Bill two hours to drive to the plant through the storm. He spotted the trouble immediately; a thermocouple and its protecting tube had burned out. It might have meant four to five thousand dollars' worth of damage.

Honeywell service begins when you first decide you need instruments, and continues long after they're installed. It includes:

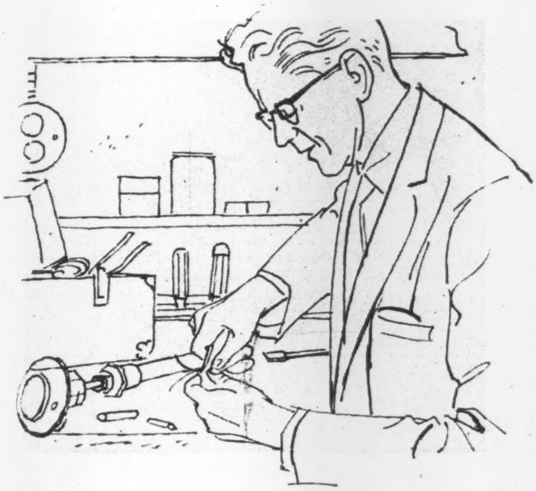
- Preliminary engineering, even before specifications are written.
- Application engineering for installation and startup.
- Service engineering help from your nearby Honeywell branch.
- Periodic service and swift help in emergencies.
- Training of your operators at the Honeywell Instrumentation Education Center.



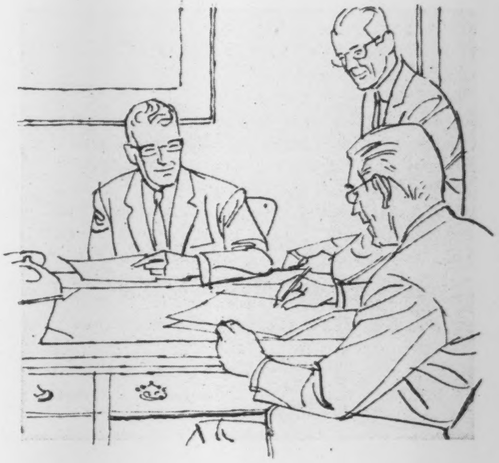
1 Bill Lewis, service engineer at Honeywell's Fort Wayne branch, was in his garage, touching up the paint on his 13-foot outboard. The bowling match had been called off that night because of the snowstorm, and Bill was glad to be home.



2 At 9:30 a call came from the Crosby Laughlin Division of American Hoist and Derrick Company in Fort Wayne. A controller on a galvanizing kettle wasn't working and unless it was fixed fast, the pot would either freeze or burn out. Bill said he would be out right away.



4 Bill didn't have a thermocouple with him that would fit, so he improvised a temporary couple and protecting tube and got the system going. Early the next morning he called the Honeywell branch in Indianapolis and had the correct thermocouple and tube shipped quickly to the plant. Next day, he carefully checked out the entire installation.



5 Now, Crosby Laughlin Division is signed up with the Honeywell Periodic Service Plan, and its complete instrumentation is checked and serviced every month. Any spare parts needed are now available at Honeywell's Fort Wayne branch. Bill hasn't had to make another emergency call to the plant since.

Around-the-clock help in emergencies is but one of many Honeywell services that give you extra value for your investment in instruments. Get the complete service story from your nearby Honeywell field engineer. He's as near as your phone.

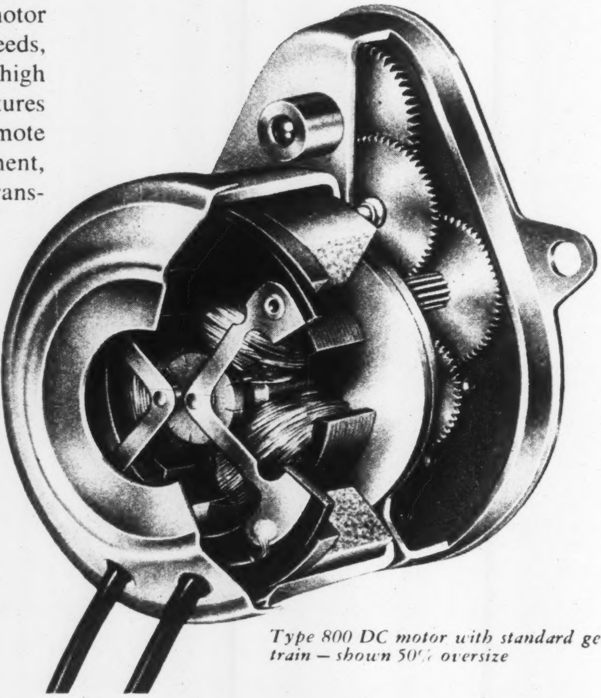
MINNEAPOLIS-HONEYWELL REGULATOR CO.,
Industrial Products Group . . . Brown Instruments,
Wayne and Windrim Avenues, Philadelphia 44, Pa.

Honeywell

H HONEYWELL First in Controls

New high-torque low-current DC motor covers extended range of output speeds

The new Cramer Type 800 direct current motor offers an unusually wide range of output speeds, coupled with low current drain, high torque, high efficiency, and excellent speed stability. These features make it the ideal choice for timing devices, remote control equipment, recorders, signalling equipment, communications gear, displays, flashers, chart transports, and many other products.



Type 800 DC motor with standard gear train — shown 50% oversize

Wide Performance Range

Depending on requirements of speed, torque, and voltage, the rotor is wound to produce a basic motor speed of 960 to 3000 rpm. A gear train then reduces this to the speed required at the output shaft. Low rotor speeds result in lower current drain at all speed-torque combinations, but limit the torque available at the higher output speeds. Higher rotor speeds require a somewhat higher input current, but greatly increase the torque available at the higher output speeds.

The Table at lower right illustrates this flexibility of design, with a few examples from the virtually unlimited range of performance characteristics which it provides. Where very low input current is required, and the supply voltage does not exceed 12 volts, the use of the low-speed rotor will provide 30 oz. in. at speeds below 3 rpm and 0.5 oz. in. at 200 rpm. The higher speed rotors meet the requirements of higher input voltages, and provide greatly increased torque at the higher output speeds with only a moderate increase in current drain. The high-torque motor has the additional advantage of speed stability within 10% from no-load to full-load, at speeds below 5 rpm.

The examples given in the Table are for illustration only. By correct choice of rotor winding and gear ratio, an unlimited number of operating specifications can be established throughout the entire range shown. The motor is also available without gear train, for output torques of 0.1 to 0.6 oz. in. at speeds up to 3000 rpm.

OUTPUT SPEEDS WITH GEAR TRAINS	960 RPM ROTOR LOW INPUT CURRENT *(3 to 12 volts DC)*		3000 RPM ROTOR HIGH OUTPUT TORQUE *(3 to 30 volts DC)*	
	INPUT VOLT-AMPERES	OUTPUT TORQUE OZ. IN.	INPUT VOLT-AMPERES	OUTPUT TORQUE OZ. IN.
2 rpd	.16	30	......	......
1/6 rpm	.16	30	.56	30
3 rpm	.35	24	.64	30
10 rpm	.35	8.5	1.04	30
30 rpm	.35	3.0	1.72	21
60 rpm	.35	1.5	1.72	12
80 rpm	.35	1.1	1.72	8.5
200 rpm	.35	.5	1.72	3.5
900 rpm	......	......	1.90	.8

Typical Performance of Type 800 DC Motors for Minimum Input Current or Maximum Output Torque

Specifications

SPEEDS — 2 rpd to 900 rpm with gear train, 960 rpm to 3000 rpm without gear train.

TORQUE — 0.1 to 0.6 oz. in. without gear train, and to 30 oz. in. with gear train.

CURRENT DRAIN — as low as 30 milliamperes, depending on voltage, load and speed.

VOLTAGES — from 3 to 30 volts DC.

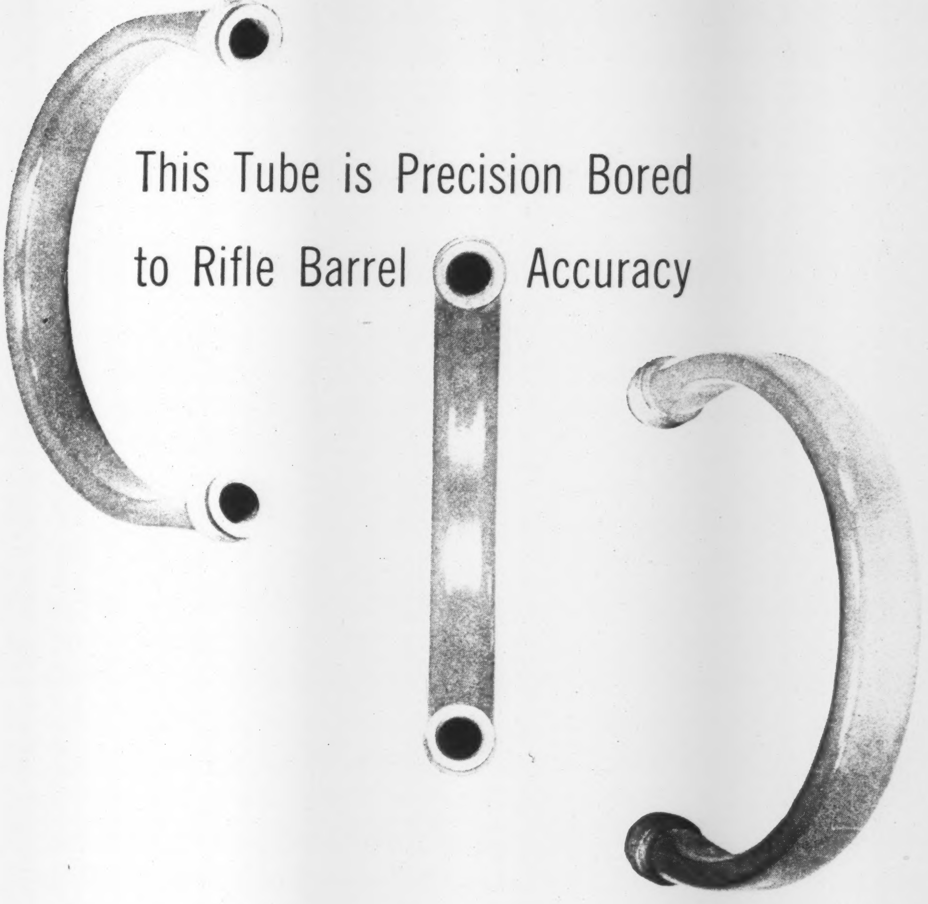
REVERSING OPERATION — with negligible speed difference, because of special motor design.

GEARS — precision-hobbed throughout, totally enclosed and with sealed-in lubricant.

For your free copy of informative Bulletin PB-800, write:

CRAMER CONTROLS
CORPORATION
Box 5, Centerbrook, Connecticut

For more information circle **40** on inquiry card.



This Tube is Precision Bored to Rifle Barrel Accuracy

The Bourdon tube in Ashcroft Duragauges is machined mirror-smooth inside and finish ground outside to exact tolerances. Strong, uniformly thick walls assure precise flexibility—sustained high accuracy and long life.

Eight tube materials permit you to select the best metal with sensitivity balanced by internal corrosion resistance. Whether your choice is phosphor bronze, an alloy steel, "K" Monel, a stainless steel or beryllium copper, metallurgical control is exact from ingot to finished tube. Socket and tip joints are welded or brazed, then stress relieved for highest strength and safety. "Whip testing" at pulsating pressures at least 50% greater than rated pressure insures calibration stability.

Order your Ashcroft Duragauges with the best Bourdon tube material for your service. Choose the all-stainless-steel movement or stainless steel with nylon bearings and pinion gear. Full range of pressures, dial sizes, case designs and materials available. In any combination of components, Duragauges give sustained high accuracy and long service. Get details from your industrial supply distributor.

100
200
300
400
500
600
800
900
1000

Ashcroft Duragauge in Phenol case — a tough, rigid plastic turret type case for wall or flush mounting.

G2-58

ASHCROFT PRESSURE GAUGES

A product of

MANNING, MAXWELL & MOORE, INC.

Consolidated Ashcroft Hancock Division • Stratford, Connecticut

In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

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Here's news about

RADIATION MONITORING

from Victoreen

To detect, measure, record or control radiation of almost any type or intensity . . . with complete systems to AEC specifications—that's *part* of Victoreen's radiation monitoring story. So no matter what your radiation monitoring problem, it will probably pay you to check with Victoreen *first*.

area monitoring

Flexible, fully proven remote area systems to AEC requirements for radiation monitoring from a single control center.

air particle monitoring

Portable air particle monitoring units to latest ORNL specifications.

fission products monitors

A reliable monitoring system based on MTR design at Idaho Falls for detection of fission product activity in coolant stream.

water monitors

For monitoring radioactive liquids in pipes, pools and streams or other locations.

neutron monitors

Fast and thermal neutron monitoring systems designed for bulk shielding and dosimetry studies.

gas monitors

Designed for continuous monitoring of radioactive stack gases. Contains built-in alarm system to operate external control circuits.

The Victoreen Instrument Company

5806 Hough Avenue • Cleveland 3, Ohio

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AA-6301

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events

April 22-25

Annual Meeting of the American Industrial Hygiene Association, Atlantic City, N. J. For additional information write George D. Clayton, Exec. Sec., 14125 Prevost, Detroit 27, Mich.

May 4-7

Fourth National Flight Test Instrumentation Symposium of the Instrument Society of America, Park Sheraton Hotel, New York City, N. Y. For more information write P.O. Box 113, Bethpage, L. I., New York.

May 6-8

1958 Western Joint Computer Conference of the Institute of Radio Engineers and the American Institute of Electrical Engineers, Ambassador Hotel, Los Angeles. For information write David Parry, 6363 Wilshire Blvd., Los Angeles 48, Calif.

May 12-14

4th National Instrumental Methods of Analysis, ISA Analysis Instrumentation Div. & Houston Section, Shamrock Hilton Hotel, Houston, Texas. Contact R. D. Eanes, L&N Stenton Ave., Phila. 44, Pa.

May 12-15

Eighth Annual Instrument Symposium and Research Equipment Exhibit at National Institutes of Health. Write James B. Davis, National Institutes of Health, Bethesda 14, Maryland.

May 14-16

Spring National Meeting of Society for Experimental Stress Analysis, Manger Hotel, Cleveland, Ohio. For information write A. G. Tokarcik, Publicity Chairman, 1958 Spring Meeting, Wheel & Brake Development, Goodyear Aircraft Corp., Akron, Ohio.

May 21-23

Instrumentation & Automatic Control of Power Systems—Today & Tomorrow, ISA Power Div. and the New York Section. Contact W. Welch, Long Island Lighting Co., L. I., N. Y.

May 27-28

Second EIA Conference on Maintainability of Electronic Equipment sponsored by the Electronic Industries Association, University of Pennsylvania, Phila., Pa. For information contact EIA office, 11 West 42nd St., New York 36, N. Y.

May 31-June 8

European Congress of Chemical Engineering and ACHEMA Congress, Frankfurt a.m., Germany. For information write DECHEMA, Dechema-Haus, Rheingau-Allee 25, Frankfurt a.m., West Germany.

June 2-4

1958 National Telemetering Conference sponsored by the A.I.E.E., A.R.S., I.S.A. and I.A.S., Lord Baltimore Hotel, Baltimore, Md. For information write T. E. Meyers, Wolfe & Mann Mfg. Co., 28th & Sisson St., Baltimore 11, Maryland.

June 4-6

Twelfth National AFCEA Convention and Exhibit, Sheraton-Park Hotel, Washington, D. C. Write William C. Copp, Exhibits Manager, Armed Forces Communications and Electronics Assoc. Convention and Exhibit, 72 W. 45th St., New York 36, N. Y.

June 9-12

1958 Microscopy Symposium sponsored by W. C. McCrone Associates, Del Prado Hotel, Chicago. For information contact W. C. McCrone, Jr., W. C. McCrone Associates, 500 E. 33rd St., Chicago 16, Ill.

June 9-13,

Fourth International Automation Exposition, Congress, Conferences, and Clinics, New York Coliseum. For information write Richard Rimbach Associates, 845 Ridge Ave., Pittsburgh 12, Pa.

June 11-13

Thirteenth Annual Meeting of the Association for Computing Machinery, University of Illinois, Urbana, Ill. For information write to the Assoc. for Computing Machinery, Jim Douglas, Jr., Math. Dept., Rice Institute, Houston, Texas.

July 14-25

Special Summer Program in the Physics of Infrared Radiation, Massachusetts Institute of Technology. For information write Dr. Richard C. Lord, Dir. of Spectroscopy Laboratory at M.I.T.

June 16-18

Second National Convention on Military Electronics, Sheraton-Park Hotel, Washington, D. C. For information write George Rappaport, Public Relations Director IRE, Inc., 1 East 79 St., New York 21, N. Y.

July 28-August 1

Gordon Research Conference on Instrumentation, Colby Jr. College, New London, N. H. For information write Dr. W. George Parks, Dir., Dept. of Chemistry, University of Rhode Island, Kingston, R. I.

Oct. 13-15

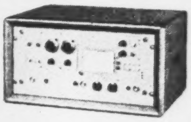
1958 National Electronics Conference—the 14th Annual Forum on Electronic Research, Development and Application sponsored by the American Institute of Electrical Engineers, Illinois Institute of Technology, Institute of Radio Engineers, and Northwestern and Illinois Universities, Hotel Sherman, Chicago. For information write National Electronics Conference publicity chairman, c/o Illinois Bell Telephone Co., 208 W. Washington St., Chicago 6, Ill.

Here's news about

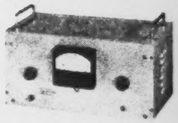
REACTOR INSTRUMENTS

from Victoreen

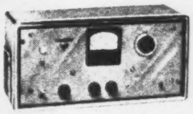
Reliable, accurate reactor instruments for use as individual components in "customized" systems . . . reactor instruments to ORNL specifications, or to your own specialized designs—that's only *part* of Victoreen's story. Perhaps best of all is that we're in production and can ship all these and many other types. Bring your reactor instrument problems to Victoreen, the *specialists in reactor instruments and instrumentation.*


model 751

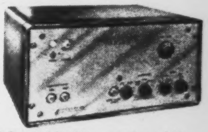
Model 751 Linear Amplifier (ORNL Spec. DD2) for scintillation spectometry, reactor control, etc., and other applications requiring high gain and resolution, good linearity, and fast overload recovery.


model 565A

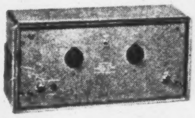
Model 565A Micro-Microammeter Electrometer (ORNL Spec. Q826B). A stable and reliable instrument for measuring low currents in ion chambers and low impedance networks.


model 727

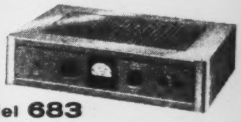
Model 727 Logarithmic Count Rate Meter (ORNL Spec. Q1454B). A wide range, five decade instrument for use with all types of radiation detectors.


model 672A

Model 672A A1D Linear Amplifier (ORNL Spec. Q1326). Amplifies low signal level pulses from radiation detectors such as ionization chambers, proportional and scintillation counters.


model 695

Model 695 Single Channel Differential Analyzer (ORNL Spec. Q1192). A differential pulse height analyzer for separating pulses of varying amplitudes.


model 683

Model 683 Ultra-Stable Power Supply. An ultra stable dc voltage source of the type required for precision scintillation counting, etc.

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Special mill services through your Superior Tube distributor

* You may be faced with the need for tubing services that only highly competent specialists at the mill can provide. You may need small tubing in hard-to-get analyses. Or of special shapes, held to very close tolerances. Or with a closely controlled range of properties. Perhaps it must also undergo rigid inspections and tests not normally available from tubing suppliers.

Requirements like these call for a tubing specialist.

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His broad experience can help you solve many problems. But most important of all—he can acquaint you in detail with many special services offered by the mill. These include statistical quality control, nondestructive tubing inspection and testing, pilot and test lot sampling and melting, field specialist and specification services—there are many more.

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For more information about Superior tubing, write for a free copy of Bulletin 40, "A Guide to the Selection and Application of Superior Tubing." Superior Tube Company, 1968 Germantown Ave., Norristown, Pa.

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The big name in small tubing

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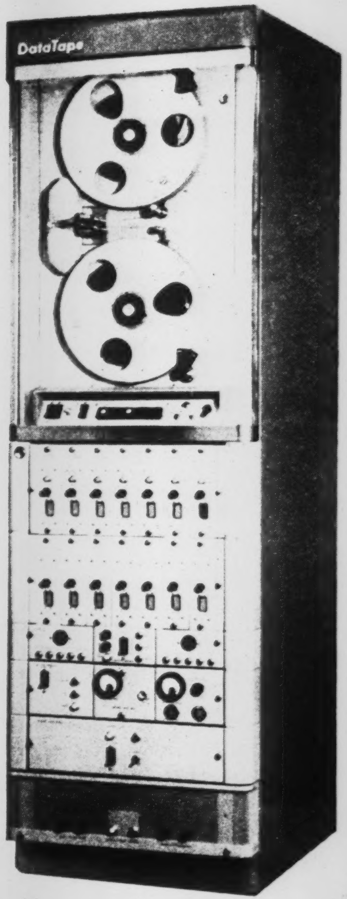
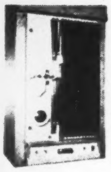
For more information circle **19** on inquiry card.

90%
of all U. S. long-range missile test flights are recorded on CEC DataTape

- quickly adaptable to use 1-mil base high-strength Mylar instrumentation Tape *
- meets IRIG specifications
- records and reproduces up to 14 tracks of information
- low flutter . . . even at low tape speeds
- system frequency response from 0 to 100 kc
- interchangeable Analog, PDM, or FM plug-in amplifiers
- uses CEC all-metal-surface magnetic heads
- provisions for remote monitoring



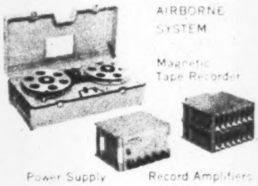
5-752 RECORDER/REPRODUCER



CONTINUOUS LOOP TRANSPORT

DIGITAL MAGNETIC TAPE RECORDER/ REPRODUCER

DATATAPE AIRBORNE SYSTEM

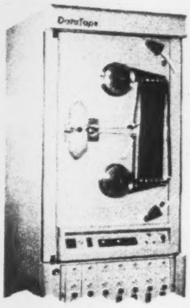


Magnetic Tape Recorder

Power Supply

Record Amplifiers

For complete information on the 5-752, write for Bulletin CEC 1576-X22.



CEC's NEW ADJUSTABLE TAPE LOOP ATTACHMENT permits the standard 5-752 Recorder/Reproducer to be converted quickly and inexpensively into a continuous loop transport for repetitive playback and data analysis. Loop lengths are adjustable from 2 to 20 feet.

* **EXCLUSIVE NEW FEATURE** of the 5-752 now permits the use of 1-mil base Mylar tape and allows 7200 feet of tape to be loaded on a 14-inch reel. Provides 50% more tape footage with radically reduced opportunity for tape breakage.

DataTape Division

Consolidated Electrodynamics

300 North Sierra Madre Villa, Pasadena, California

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For more information circle **43** on inquiry card.

editorial

The IRE Show

The statistics of the IRE Show are in themselves startling—17,000 pieces of exhibited apparatus, 850 exhibitors, 2½ miles of booths, 280 technical papers, etc., etc. All branches of the electronic art and science from nucleonics to medical electronics were covered both by exhibited apparatus and by technical papers.

Yet behind the glitter and the glamor and the sensational novelty, it appeared to your editors, who spent the week both touring the exhibits and sampling the papers, that the field of electronics has settled back into a period of healthy slow development and attention to details, to unsensational but important advances in hardware and components, to extension of ranges by all-important factors of 5 and 10 percent.

Digital Techniques

Neither analog nor digital techniques can be considered "new" this year. But noteworthy was the introduction of several new lines of digital logic-type plug-in-type elements that permit rapid development of data-handling systems, digital computers, special-purpose computers, logic systems, control systems, etc. These were introduced by Harvey-Wells Electronics, Mack Electronics Div. of Mack Trucks, Inc., and Digital Equipment Corp.

The field of digital techniques for computation and control via symbolic logic, matrix systems and plug-in digital circuits, is one of tremendous and relatively untapped potential, and involves concepts that are new to most process engineers. Thus the 90-minute lecture-demonstration clinic classes on these techniques (which will be held at the Fourth International Automation Exposition) to be given by Computer Control Company and Engineered Electronics Company are of particular importance to all process engineers, as are the clinic sessions on general-purpose digital computers (Bendix Aviation), process control by digital computer (Thompson-Ramo-Wooldridge), Compu-Tronics (National Cash Register), Input Output Digital Devices (Potter Instrument Co.) and static punched card sensing (Taurus). These are recommended by your editors as an enjoyable and powerful way to learn the many new concepts involved. More details are given on pages 614 and 657.

In commenting on digital techniques, an important new book was introduced at the IRE show by Instruments Publishing Company. The book *DIGITAL TECHNIQUES FOR COMPUTATION AND CONTROL* by Dr. Martin Klein, et al, is a long-awaited work that will be a major contribution to this field.

Analog Techniques

Year after year your editors have singled out analog computers as devices of great potential for the process industries. At the IRE Show, Mid-Century Instrumatic unveiled the 48-amplifier MC-5800 with high flexibility for input-output devices; Donner Scientific introduced a desk-top analog computer; Electronic Associates exhibited the powerful 231R PACE; Beckman exhibited its expansible EASE; and the new D series high-speed analog computers of GPS Instrument Company aroused great interest.

Here again is a field requiring new concepts and techniques of the working process engineer, and here again the clinic classes of the Fourth International Automation Exposition offer every engineer an opportunity to learn them quickly. Electronic Associates and GPS Instrument Company will cover both the principles and applications of real-time and fast-time analog computers (see pages 614 and 657).

Components and Hardware

As has been mentioned, the major emphasis at the vast show was on components and hardware. Among the many components of particular interest to process and instrument men was the new "Sensistor" of Texas Instruments, a silicon resistor with stable positive temperature coefficient of 0.7%/C°. This suggests use as a temperature detector or compensator.

Printed circuits, plug-in modules and miniature components are the obvious trend in the fabrication field.

Recorders

The past few years have seen exciting developments in recorders, a third field with extraordinary growth potential. If there could be a single "outstanding" disclosure at the IRE Show, your editors would vote for a small recorder that operates on the oldest principle known to recording. This is the RUSTRAK miniature chopper-bar-type recorder of Rust Industrial Company, and it earns our vote not because of its size, accuracy and simplicity, but because of its very low price.

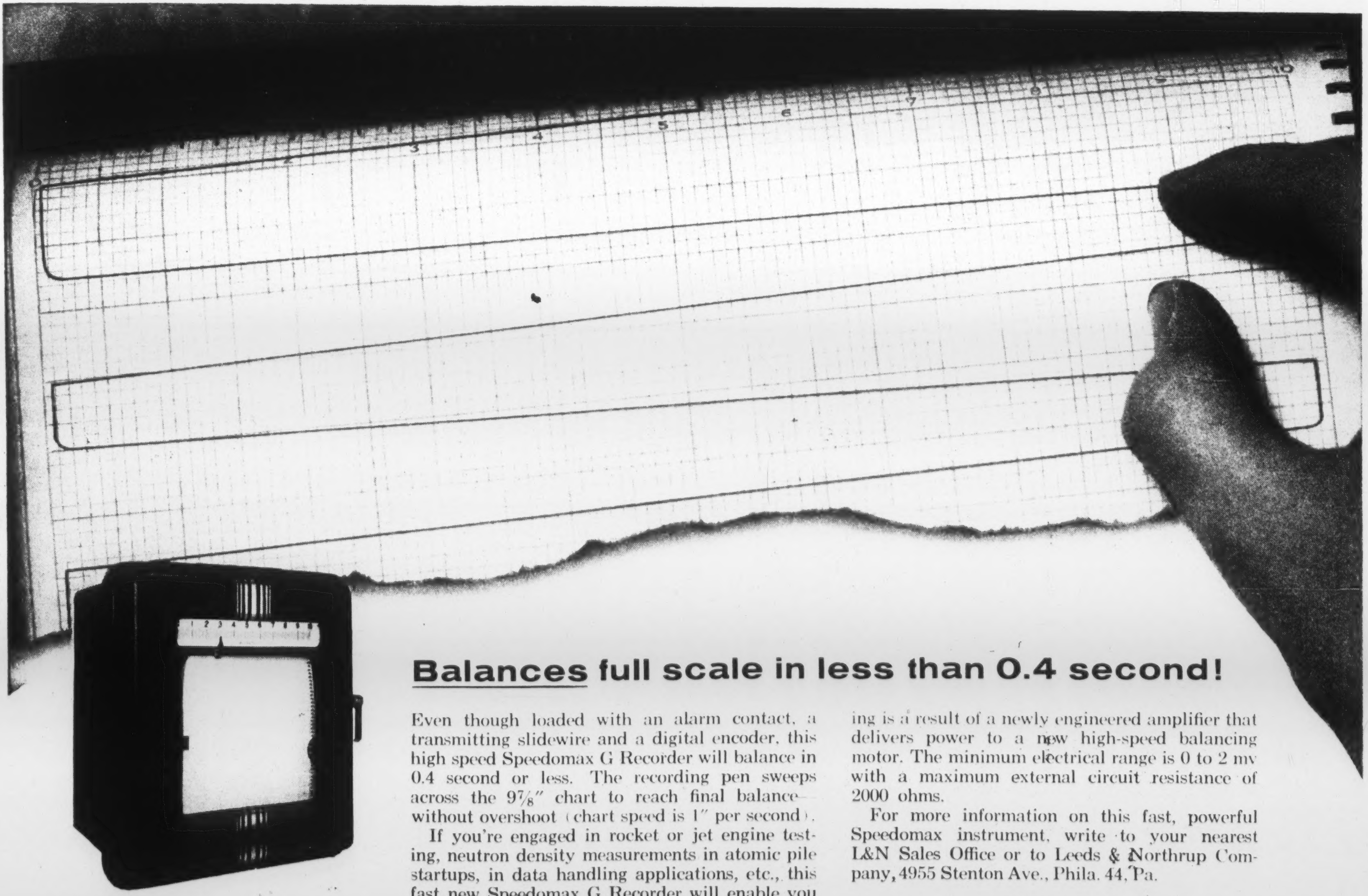
This recorder, plus the many others at the IRE Show, will be discussed in our May issue, devoted entirely to recorders.

Medical Electronics

The field of medical electronics, although represented by a few papers and a few important developments, such as the spectroanalytic analyzer of FTL-ITT, was described by Walter E. Tolles (chairman of the IRE session on Medical Electronics) as "not yet an industry" and a "long way from being big business."

This situation is caused in part by lack of support for medical research by our nation, individually and collectively, and in part by lack of knowledge of electronic equipments and instruments by the practicing physician, diagnostician, therapist, and researcher.

Hence your life and future welfare is affected by the news that a national trade publication devoted entirely to medical electronics will soon appear and reach 30,000 workers in the field of medicine. This news evoked great interest at the IRE show. It is fitting that this publication is being brought out by Instruments Publishing Company, the company that brought out a magazine in the field of instrumentation (this publication) thirty years ago—when instrumentation also was "not yet an industry." For the sake of mankind, we pray that 30 years from today the field of medical electronics will achieve the stature of the instrument industry of today.



Balances full scale in less than 0.4 second!

Even though loaded with an alarm contact, a transmitting slidewire and a digital encoder, this high speed Speedomax G Recorder will balance in 0.4 second or less. The recording pen sweeps across the 9⅞″ chart to reach final balance—without overshoot (chart speed is 1″ per second).

If you're engaged in rocket or jet engine testing, neutron density measurements in atomic pile startups, in data handling applications, etc., this fast new Speedomax G Recorder will enable you to measure and record extremely fast changes in the d-c millivolt signal under test.

This fast balancing speed with instrument loading is a result of a newly engineered amplifier that delivers power to a new high-speed balancing motor. The minimum electrical range is 0 to 2 mv with a maximum external circuit resistance of 2000 ohms.

For more information on this fast, powerful Speedomax instrument, write to your nearest L&N Sales Office or to Leeds & Northrup Company, 4955 Stenton Ave., Phila. 44, Pa.

LEEDS NORTHRUP
Instruments
Automatic Controls • Furnaces

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Fourth International Automation Exposition

CLINIC CLASSES

COMPUTER CONTROL OF CHEMICAL PROCESS PLANTS—**Thompson-Ramo-Wooldridge Products Co. Separate classes on:**
- Computer control of oil refineries and chemical process plants.
- Automatic test control and data reduction
- Profit improvement via on-line control
- Test time savings via control and data reduction at the test site.

HIGH-SPEED ANALOG COMPUTERS—**GPS Instrument Co., Inc.**
- Features and advantages of high-speed computers vs real time computers. Typical applications.

THE ANALOG COMPUTER IN CONTROL SYSTEM DESIGN—**Electronic Associates, Inc.**
- The nature and capabilities of the analog computer
- Applying the analog computer to the design process
- Simulating a control system

LOGICAL DESIGN AND DIGITAL TECHNIQUES—**Computer Control Company**
- Design of digital systems using block technique
- The logical element and logic mathematics
- Unitized logical elements

DIGITAL COMPUTER TECHNIQUES AND PRACTICE—**Royal McBee Corporation**
- Digital computer elements and operation
- Instruction and programming
- Typical applications
- Demonstration and discussion of the LGP-30.

DIGITAL COMPUTER PRINCIPLES AND APPLICATIONS—**Bendix Aviation**
- Elements of the general purpose digital computer
- Instructions and programming
- Demonstrations and examination of the G-15 general purpose digital computer and accessories
- Intercom 1000—a system offering floating decimal point arithmetic with fixed or floating point input and output.

ANALYSIS AND OPTIMAL CONTROL OF CHEMICAL PROCESSES—**Quarie Controllers**
- Analysis of process characteristics—a disclosure of new techniques for analysis and optimal control.
- Types of characteristic curves for chemical processes
- The Quarie Controller for optimal control.

COMPU-TRONICS—**National Cash Register Company**
- Disclosure of a new technique and new equipments

ELECTRONIC CIRCUITS VIA PLUG-IN MODULES—**Engineered Electronics Co.**
- Features of modern plug-ins.
- Developments of circuits with modules.
- Symbolic logic circuits

AUTOMATIC PROGRAMMING AND TESTING VIA STATIC PUNCHED CARD SENSING—**Taurus Corp. (Metron)**
- The static punched card sensor with 540 positions, a new approach to automatic programming and testing. Features and applications.

GAS ANALYSIS BY THERMAL CONDUCTIVITY—**Gow-Mac Instrument Company**
- Principles of gas analysis by thermal conductivity
- Chromatography
- Typical applications and demonstrations

PLANT ECONOMICS WITH OPERATIONS RECORDERS—**Gorrell & Gorrell**
- Use of recorders for analysis of plant operations
- Economics of recording and analysis
- Multi-point recording

WEIGHT, LOAD AND STRAIN CONTROL IN INDUSTRY—**Baldwin-Lima-Hamilton Corp.**
- Principles and practice of SR-4 techniques
- Applications in weight, load, torque, strain, etc.
- Current status of SR-4 devices in automation

FLOW MEASUREMENT AND CONTROL WITH TURBINE FLOWMETERS—**Potter Aeronautical**
- Principles of Pottermeter turbine-type flowmeters and related instrumentation
- Typical applications in flow measurement and control
- Calculations for mass flow, digital readout, etc.

PRESSURE CONTROL WITH PRESSURE SWITCHES—**Gorn Electric Co., Aircraft Control Co. Div.**
- Principles and practice of pressure switches
- Selection and application factors
- Typical applications in aircraft and industry

STRUCTURAL PARTS FOR PRINTED CIRCUITRY—**Gorn Electric Co., Electronics Div.**
- New concepts in printed circuit board packaging
- Structural parts and connectors
- Assembling actual circuits with "Gornets" and "Gornectors"

LEVEL AND FLOW CONTROL—**McIntosh Equipment Corp.**
- Principles and applications of all types of on-off level and flow controllers.

POTENTIOMETER RECORDERS—**The Bristol Company**
- Principles of self-balancing recording
- Applications in industry and research
- High-speed self-balancing techniques

PHOTOGRAPHIC TECHNIQUES FOR AUTOMATION—**Karl Heitz, Inc.**
- Survey of photographic techniques
- Automatic techniques involving photography
- High-speed photography

PRECISION ELECTRO-MECHANICAL COMPONENTS AND SERVOS—**PIC Design Corp.**
- Precision instrument systems using electro-mechanical parts
- Electro-mechanical servos
- Use of stock parts for precision systems

SELECTIVE DATA PRINTERS—**Copy-Craft, Inc.**
- Survey of need for selective data printers
- Data printing techniques
- The Ormig selective data printer
- Typical applications in production control, accounting, etc.

PROCESS SCANNING AND LOGGING TECHNIQUES—**Panellit Corp.**
- The integrated process control system with scanner-logger
- New scanning and logging techniques
- Typical applications
- Built-in computing devices

MATHEMATICAL TOOLS FOR RAPID DATA ANALYSIS—**Gerber Scientific Instrument Co.**
- Applications of the variable scale in engineering problems
- Graphical-numerical computing devices and problems solvable on the GraphAnalogue—linear interpretations, frequency analysis, etc.
- Obtaining derivatives of curves
- Fitting equations to curves via the Equameter

CONTROL SERVO SYSTEMS—**Waldorf Instrument Co.**
- Servo building blocks for digital indicators, integral servo driven analog indicators, analog-to-digital converters, etc.
- The "Micromation" concept

ELECTRO-MECHANICAL COMPUTER ELEMENTS—**Waldorf Instrument Co.**
- Miniature differentiators, integrators and vector solvers for typical analog computations

PRECISION DIMENSIONAL MEASUREMENT & CONTROL—**Datex Div., G. M. Giannini & Co.**
- Application of shaft-position encoders in the laboratory and in the machine-tool industry; principles and applications

OFFICE RECORDING TECHNIQUES—**Miles Reproducer Co.**
- The problem of conference recording
- Synchronized indexing, corrections, case histories.

AIR AND GAS MOISTURE CONTROL—**Trinity Equipment Corp.**
- Drying air and gases at pressures to 5000 psi.
- Vapor and dewpoint fundamentals.
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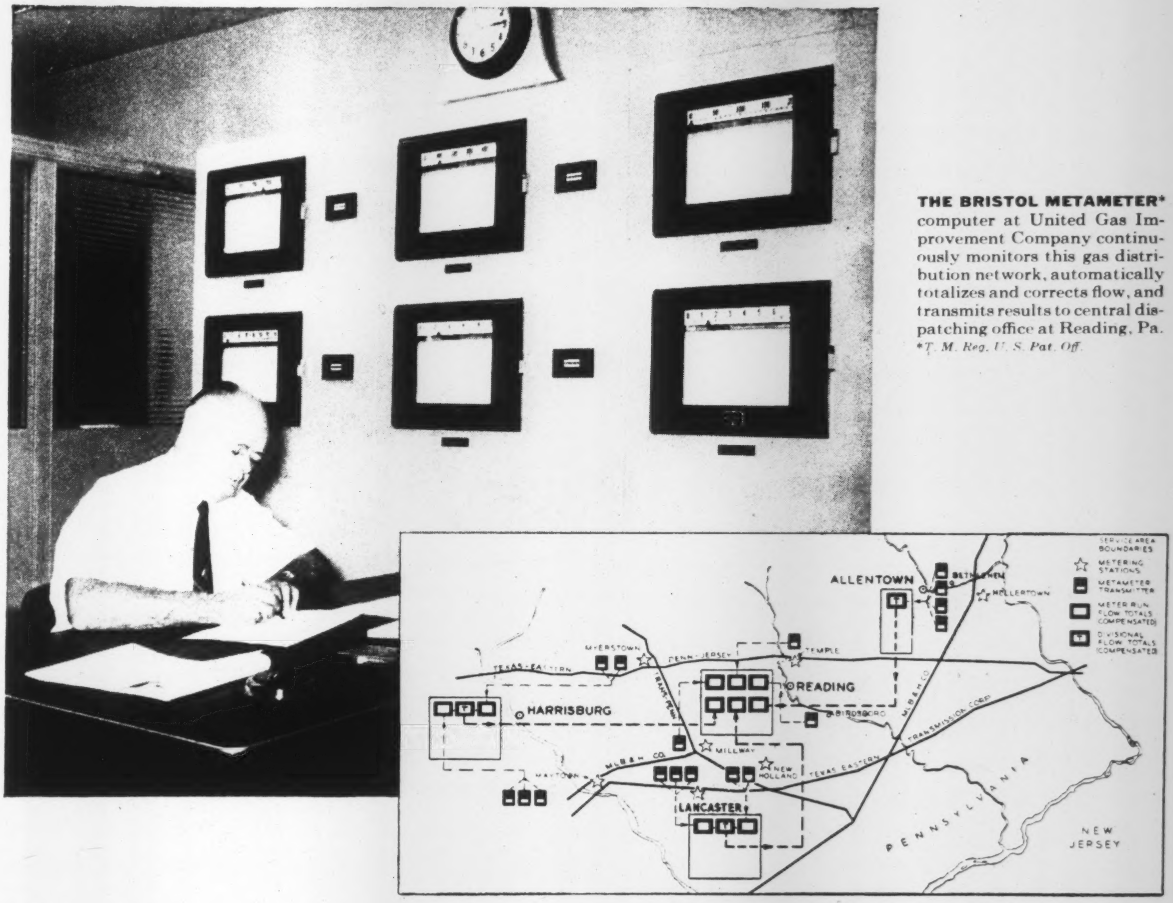
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This introduction to nuclear reactor physics presents (1) nuclear structure, (2) the energies involved in nuclear bonds, (3) mass-energy relations, (4) the environment required for a chain reaction, and (5) the various types of nuclear reactors.

A. A. MARKSON
Hagan Chemical & Controls, Inc.

INTRODUCTION TO REACTOR PHYSICS

NUCLEAR transformations, fisson in particular, are the present basis of atomic power. A sort of chemistry of the nucleus has arisen reminiscent of ordinary inorganic and organic chemistry, but with one enormous difference. Ordinary chemical reactions seldom involve energies of over 1 ev (electron volt): nuclear reactions run into kev, Mev, and Bev energies (thousand, million and billion electron volts).

Units of Energy

Energy units used in the atomic energy field are generally based on the centimeter, gram, and second (C.G.S.) system. From high-school physics we recall that the *erg* is the basic unit of energy, the work done against gravity in raising a one gram mass one centimeter, or a dyne centimeter. The *joule* is the practical energy unit, equal to 10,000,000 ergs.

4.183 joules equal one small calorie, thus relating work and heat. A joule per second is a watt, the power unit common to both English and metric systems.

The term *electron volt* (ev) is encountered throughout the atomic field. An electron volt may be defined as the energy required to move a unit (electron) charge through a potential of 1 volt. It is a small unit in nuclear reactions and therefore kev, Mev, Bev respectively are encountered as thousand, million and billion electron volts. The electron volt is well suited for expressing charged particle energies, and is convertible by transformation constants into the more familiar energy units.

The potential at a point is measured by the work required to bring a unit positive charge to that point from a region far removed from electric charges, from infinity, mathematically. Consider the unit charge as the charge of one electron or proton. This quantity of charge is minus or plus, as the case may be. The work is plus or minus depending on whether the charges repel or attract.

Alternately, the *kinetic energy* gained by an electron in falling through a potential difference of one volt also can be expressed as one electron volt (ev).

Thus $(\frac{1}{2})mv^2 = kE$, where E is in electron-volts, k a constant.

This relationship is useful in calculating particle velocities in an electric field when the mass, charge and potential are known.

Since mass and energy are convertible by the Einstein equation ($E = mc^2$), other relations follow:

$$E \text{ (calories)} = m \text{ (grams)} \times 2.15 \times 10^{13}$$
$$E \text{ (electron volts)} = m \text{ (grams)} \times 5.61 \times 10^{32}$$
$$1 \text{ calorie} = 2.62 \times 10^{19} \text{ electron volts.}$$

If the mass is expressed on the physical atomic weight (mass) scale, by introducing Avogadro's number* into the gram equations:

$E \text{ (Mev)} = 931 \times \text{Mass}$ (on the atomic weight scale)

By this equation one takes a given difference of masses (given by the physical atomic weight scale) and multiplies this by 931 to give the hypothetical conversion energy value in millions of electron volts.

A relationship between photons of definite wavelengths and the energy of such photons is defined by Planck's monumental relationship:

$$E \text{ (ev)} = h\nu = hc/\lambda$$

where h = Planck's constant, ν = frequency, c = velocity of light in vacuo, λ = wavelength.

As a memory aid, one electron volt approximately corresponds to 12345 Angstrom units. This is in the infrared. From this, 4000-AU radiation (in the extreme violet) is approximately 3 ev, which is sufficient to ionize the most loosely bound outer electron and is of the order of chemical ionization potentials which are concerned with valence electrons only.

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*Avogadro's number tells us that there are 6.02×10^{23} atoms in a mass in grams of an element equal to its atomic mass as given by the physical atomic mass table.

Nuclear Structures

Physically, the atom is said to consist of a nucleus plus orbital electrons. Almost all of the mass resides in the nucleus as protons and neutrons. The number of protons is commonly called the *atomic number* (Z), which is also the number of orbital electrons in a neutral atom. The *mass number* of an element (A) is the sum of the neutrons and protons (Z + N). Note that the number of neutrons equals A − Z. The mass number is almost, but not quite, the same as the physical atomic mass.

In discussing a particular nuclear structure, the term *nuclide* is encountered. Nuclide applies to atom species as characterized by the properties of their nuclei: a nuclide is a complete nucleus.

A *nucleon* is a proton or neutron, a constituent of an actual nucleus or nuclide.

Isotopes of elements are nuclides which have the same number of protons as the element. This number is the element's atomic number and unambiguously names the element. The atomic mass of an isotope differs in mass from other elements of the same atomic number by the number of neutrons in the nucleus. (In the older chemistry, isotopes were stated to be indistinguishable by ordinary chemical means.)

The 1957 edition of the *Handbook of Chemistry and Physics* lists over 600 isotopes, mostly man-made. Uranium, for example, has 14 isotopes listed, all radioactive, the majority being artificial.

Nuclear *isobars* are nuclides of different elements having the same mass numbers. For example, P^{32} and S^{32} are isobars; A is the same for isobars, but Z and N are different.

The use of the superscript for atomic mass is sometimes replaced by writing the mass "in line," although the standard convention is to write the atomic number as a subscript and the mass as a superscript. Thus $_2He^4$ refers to that isotope of helium, atomic number 2, whose mass number is 4. This can also be written as He4.

Nuclear *isomers* are atoms having both the same atomic number (Z) and the same atomic mass (A). The nuclei differ in radioactive states of excitation energy.

An unfortunate thing took place because of the existence of isotopes. Oxygen, on the International Chemists Atomic Weight Scale, is arbitrarily 16. However, oxygen exists in the atmosphere as 99.76% of an isotope of mass 16, together with 0.04% of oxygen of mass 17.0045 and 0.2% of a third isotope of mass 18.0049. The weighted mean of these values is 16.0044 so that atmospheric oxygen has a mass of 16.0044 on a Physicist's Atomic Mass Table, whereas the chemist's 16.0000 is based on the natural mixture. Such minute differences are very important in nuclear energy calculations. The ratio of the two scales is 1.000275.

Packing Fraction and Binding Energy

If the nucleus consists of neutrons and protons, both of which have masses of almost unity, then the atomic weights of all elements should be very close to whole numbers because the electrons weigh almost nothing. A surprisingly large proportion of the natural elements have atomic weights which differ from integral values by considerable amount, such as 0.1.

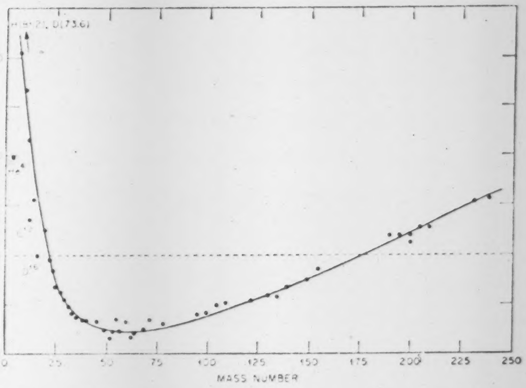

FIG. 1. ASTON'S PACKING fraction curve for stable nuclides. This represents mass excess or deficiency—that is, the difference between actual mass and theoretical (built-up) mass.

If the atomic mass, to the nearest whole number, is taken as a reference, the difference between this number and the actual atomic mass gives the "excess" or "deficiency" of theoretical mass. This difference divided by the mass number is a very minute fraction, so that F. W. Aston in 1927 proposed a definition of this relationship (called the *packing fraction*) as follows:

P. F. = 10,000 (Isotope Mass—Mass Number)/Mass Number, where the mass numbers are integers, or whole numbers.

Fig. 1 shows a curve of Aston's packing fraction for stable nuclides. Although He, C and O do not fall on the curve, and although there are other deviations, qualitatively the light elements up to sodium show a positive fraction, the isotopes between sodium and tantalum show a negative fraction, and above tantalum the fraction is positive.

A negative packing fraction suggests that there may have been a conversion of mass into energy when nature made these nuclides. Thus, if it were possible to synthesize nuclides up to almost mass number 50 (say by raising the mass number by adding protons), enormous energy would be released. But to carry this simple concept above mass 50 it would seem impossible to get energy. In fact it would have to be absorbed.

On the other hand, if we start at about mass 240 we could, by a process of decomposition of nuclides, produce elements down to mass 60 in accordance with this notion, again with great energy releases. This is fission, and we come to the striking conclusion that there seems to be no direct way of splitting the heavy elements into the primary building blocks or even into atoms lighter than mass 50 or so. This suggests that nature may have used two different processes in producing all the elements.

If we used the exact masses of the neutron, proton and electron (rather than the integer values) we could calculate a more exact set of mass excesses or deficiencies. Remembering that one proton demands one

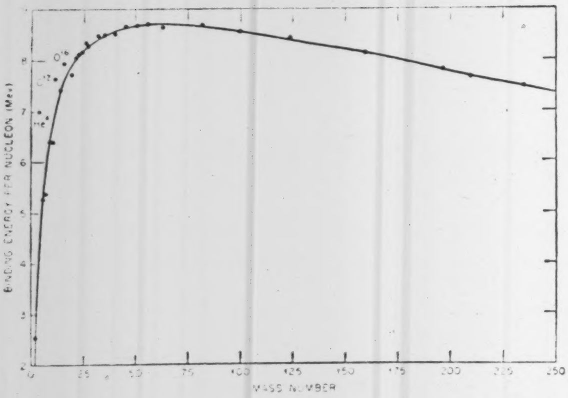

FIG. 2. BINDING ENERGY per nucleon as a function of the mass number for stable nuclides. This represents energy equivalent in Mev of the true mass excess or deficiency. Energy per nucleon can be converted into energy per nuclide by multiplying by the true mass number of the nuclide.

orbital electron, and neglecting an exceedingly minute mass change when one proton unites with one electron to give hydrogen, we can use the mass of the neutron and the hydrogen atom for calculating a "true" mass number of any element.

Thus, an atom of Z protons and A — Z neutrons (A being the ordinary mass number) would have a calculated built-up value of:

$$(Z)(\text{Mass of hydrogen atom}) + (A-Z)(\text{Mass of neutron})$$

This value would differ from the actual isotope mass by the true mass deficiency or excess. This is called the *true mass defect*, ±. We may apply Einstein's equation to this "discrepancy" by multiplying this value by 931 (as described earlier). We now have the equivalent of the mass defect in Mev and therefore, a quantitative figure for mass-energy transformations in general.

For a given nuclide we will call this result the *binding energy* of the nucleus:

$$\text{B.E.} = 931\ [Z(\text{Mass}_H) + (A-Z)(\text{Mass}_N) - (\text{Actual Mass})]$$

where the masses are *exact* mass numbers.

The curve of the binding energy versus mass number is shown in Fig. 2; it is almost an inversion of Fig. 1. Note the broad maximum at about 8.7 Mev, and that the B.E. is about 7.5 Mev for uranium. It is this *difference* which is the source of fission energy.

Note the even greater difference in binding energy that exists between hydrogen and any heavier element (up to the peak of the curve). This is the source of fusion energy.

Note that the curve in Fig. 2 is binding energy *per nucleon.* Remembering that a nucleon is one proton or neutron, and that one nuclide has a number of nucleons equal to its mass number, then any energy figure taken from this curve can be converted into energy for a given nuclide by multiplying the figure by the exact mass number of the nuclide.

Nuclear Reactions

According to Einstein's mass-energy equation, the nuclear reaction energy must be exactly balanced by the changes of mass in the reaction. For example, if a process releases energy (Q positive) there is less mass after than before, whereas if the process absorbs energy there is more mass produced, implying that the total mass of the products exceeds that of the original particles. Let us look at the historic transmutation reaction studied by Cockcroft and Walton in 1932 when they bombarded Lithium^7 with protons, forming 2 alpha particles. This reaction is:

$$_3Li^7 + {}_1H^1 = {}_2He^4 + {}_2He^4 + Q\ (17.2\ \text{Mev})$$

It was the first purely artificial transmutation reaction brought about by man by use of a particle accelerator. Note that the lithium isotope of mass 7 and 3 protons captures a proton (a hydrogen nucleus) with the production of 2 helium atoms. The helium atom state He^4 is known as an alpha particle.

Let us abbreviate this reaction according to a scheme devised by Hans Bethe in 1935. Although the convenience of denoting the atomic number is worthwhile, the naming of the atom and its nuclear mass really takes care of this because the atom's name is completely connected with its atomic number. Bethe's system writes the reaction as follows:

$Li^7\ (p,\alpha)\ He^4$. This is called a (p,α) reaction. This states that the isotope of lithium of mass 7 has engulfed protons, released alpha particles, the end result being helium.

In this reaction Q is 17.2 Mev. Since 17.2 Mev equals m (atomic weight) x 931, by Einstein's equation m = 0.0185. Since there is a liberation of Q, we should expect the mass of resulting helium to be less by 0.0185 units than that of the original lithium and proton.

The actual isotopic weights are known with considerable accuracy. Thus,

$$\begin{array}{rlcrl} Li^7 = & 7.0182 & \qquad & He^4 = & 4.0039 \\ H^1 = & \underline{1.0081} & & He^4 = & \underline{4.0039} \\ & 8.0263 & & & 8.0078 \end{array}$$

The difference is 0.0185, thus confirming the mass energy law, since confirmed abundantly.

The mass of certain unstable or rare nuclides are now actually determined by this relationship when direct methods are unavailable. This expresses the present state of confidence in the Einstein equation.

It is probable that the first step in an artificially produced nuclear transformation is the formation of a compound nucleus due to coalescence of a projectile (particle) with the target (a nucleus). This nucleus, having excessive energy, will often break up.

If the projectile is a neutron, there should be almost no potential barrier resisting its entry into the nucleus because the neutron has no charge. Hence neutron reactions are common. Neutrons of any velocity can react with every known atom but helium. (Helium is the most stable nuclide known.)

Sometimes the energy of a compound nucleus is not enough to expel nucleons (nuclear particles) after bombardment. In this case some or all of the excess radiation is released as gamma radiation photons. This is common in neutron reactions.

The neutron symbol in this event would be (n, γ)—that is, following the Bethe notation, an (n, gamma) process.

The simplest (n, γ) process occurs with a slow neutrons as follows:

$$_1H^1 + {}_0N^1 = {}_1H^2 + \gamma$$

otherwise written,

$$H^1 \ (n, \gamma) \ H^2$$

This describes the reaction when slow neutrons bombard a hydrogen target. The end product is deuterium, heavy hydrogen, with the release of gamma radiation.

The possibilities of bombardment reactions are many, including the discovery of the new transuranium elements. Neptunium was the first, discovered by McMillan and Abelson in 1940, using slow neutrons. This historic reaction is:

$$U238 \ (n,\gamma) \ U239$$

and

$$92U239 \rightarrow 93Np239 + e^-$$

The Fission Reaction

It was stated that neutrons will react with any known element except helium. The product of this reaction is not necessarily fission of the target. For fission, the nucleus must satisfy two conditions. First, it must be fissionable. Second, since spontaneously fissionable materials would have disappeared eons ago, the fissile material must be struck by a neutron which can furnish the right triggering energy. (This is similar to a mixture of oxygen and hydrogen capable of remaining in an inactive state until spark energy is applied.)

The binding energy of the nucleus is measured by the mass which would be converted into energy if the particular atom were to be assembled from its component parts.

When the slow neutron hits a U235 atom and U236 is formed:

$$B.E.\ U236 - B.E.U235 = 6.6\ Mev$$

When a slow neutron hits U238 and U239 is formed:

$$B.E.\ U239 - B.E.\ U238 = 5.3\ Mev.$$

Now, according to the simplified Bohr-Wheeler treatment, the critical triggering energy for U238 is 5.9 Mev, compared with 5.3 Mev for U235. This makes the rarer isotope more fissionable by slow neutrons because the addition of a neutron with zero kinetic energy raises the U235 nucleus above the critical value, but fails to do so by 0.6 Mev in the case of U238. Therefore, 0.6-Mev neutrons (fast neutrons) are required for the fission of U238. In practice, neutrons of 1 Mev are needed. Similar considerations apply to the fission of thorium 232, protactinium 231 and neptunium 237, all of which require fast neutrons.

An odd number of neutrons characterizes the easy-to-fission isotope. Thus, U233, U235 and Pu239 contain even protons and odd neutrons and are fissionable by slow neutrons. N_p237, Th232 and U238 require fast neutrons because they have an even number of neutrons.

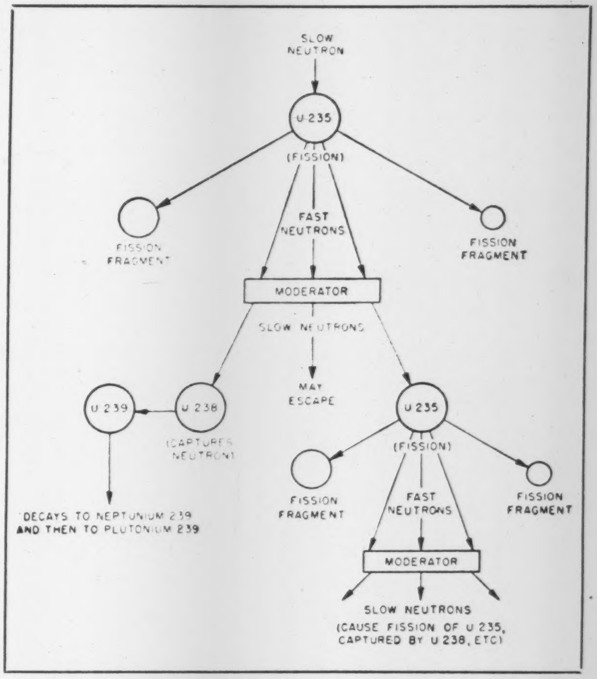

FIG. 3. EVENTS in a chain reaction.

In constructing the background of chain reaction, two unique properties of the neutron should be kept in mind.

First, the neutron is capable of reacting with every known atom but helium, and this applies to neutrons of any velocity. This property of universal reactivity does not depend at all on extreme particle energies.

Second, the reaction yields are uniquely good. For example, one incident neutron can and does produce more than one product neutron in the fission reaction (Fig. 3). Obviously, it is this property which is the key to a chain reaction.

The results of slow neutron fission of U235 are summarized by the following data. First, the approximate energy balance is shown in Table 1.

TABLE 1—U235 FISSION ENERGY RELEASE

Kinetic energy of fission fragments	168 Mev
Beta particles and neutrino energy	17 Mev
Fission neutron kinetic energy	5 Mev
Gamma rays	11 Mev
Total	201 Mev (±6)

This checks well against direct binding-energy figures of about 200 Mev. and direct measurements by calorimetry, etc.

Fig. 4 is a classic distribution curve for the products of a fission of U235 by slow neutrons. Note that the peaks of maximum yield fall within two groups—(1) a light group with mass numbers from 85 to 104 with a peak at about 95 and (2) a heavy group from about 130 to 148, with a peak at about 140. Thus, fission is not a matter of equal fragments; there is a plane of symmetry about mass number 117 for the fragment distribution.

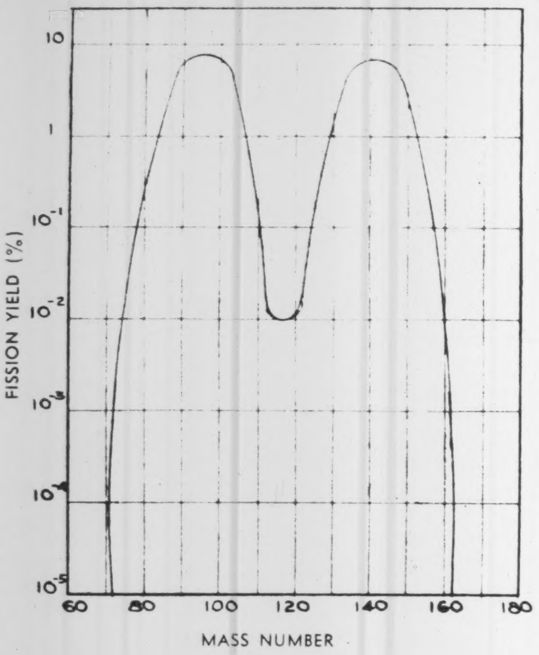

FIG. 4. FISSION YIELD (products formed) by fission of U235 by slow neutrons.

Neutron Emission

Neutron emission is the key to chain fission. When a neutron strikes its target (perhaps the nucleus of a uranium atom) an intermediate fission product may be formed. The fission product may be radioactive (unstable), expressed in terms of short half-life. Hence the emission of some neutrons or other particles from the fission product can be delayed, depending on the half life of the source, although most neutrons appear "right now."

In the fission process with uranium, many of the fission products (Fig. 4) are neutron emitters. The delay in neutron emission depends on the half life of each product, as shown in Table 2.

TABLE 2—YIELD OF DELAYED NEUTRONS AND NEUTRON ENERGY OF VARIOUS PRODUCTS OF FISSION FORMED WHEN U235 IS BOMBARDED WITH SLOW NEUTRONS.

Half-life of emitter, sec.	% Yield of Neutrons	Energy, Mev
55.6	0.05	0.25
22.5	0.17	0.56
4.51	0.21	0.43
1.52	0.24	0.62
0.43	0.08	0.42
0.05	0.025	
	Total 0.75%	

Neutron Types

The velocity spectrum of neutrons extends roughly from about 0.01 ev to well over 20 Mev in terms of energy. A 0.001-Mev neutron (1000 ev) has a speed of 430,000 meters per second, whereas a 1-Mev neutron has a speed of about 14,000,000 meters per second. A neutron with an average energy of 0.025 ev is pretty much in the same state of thermal agitation as its surroundings. Its energy varies with temperature and it is, therefore, called a *thermal neutron*. However, it is still in lively motion, having a speed of perhaps, 2,000 meters per second.

For convenience, neutrons having energies up to about 100 ev are called *slow* neutrons. The term *epithermal* neutrons applies to neutrons in the range above thermalization and below 100 ev.

A roughly defined range from 100 ev to 0.1 Mev is called *intermediate* neutrons, while *fast* neutrons are again roughly defined from energy levels of 0.1 Mev and up.

When the reacting neutron is in the resonance capture range of the target it is called a *resonance* neutron.

Nuclear Cross-Sections

The cross-section concept is an engineering simplification of some complex reactor engineering ideas.

The efficiency of nuclear reactions involving bombardment can be stated in terms of the number of particles emitted (nuclei undergoing transmutation) for a given number of incident particles. The efficiency is vanishingly low for practically all bombardment processes, 0.1% being a very substantial figure. Neutrons are the big exception.

Incident particles can produce a reaction only when they hit the target "bullseye," thus the size of the target will govern the number of bullseye hits per 100 projectiles. If a bombardment takes place with relatively high efficiency, the target cross-section can be considered large for the particular reaction. This simple physical idea is in widespread use because it can represent many important properties of nuclear reactor materials. There can be fission cross-section, absorption cross-section, scatter-capture cross-section, etc.

Suppose I is the number of particles striking one square centimeter of target. Let A equal the number of these nuclei which undergo reaction as a result the I particles. The efficiency is A/I.

Suppose Δ square centimeters is the cross-section area per nucleus apparently 100% effective for the process, the remaining area having no effectiveness. Suppose too, that there are actually N particles per square centimeter of target area.

Then, the number of particles really effective is $N\Delta$ per square centimeter.

This is also the fraction of bullseyes or reactions scored by I incident particles, or $A = N \Delta I$, from which $\Delta = A/NI$ square centimeters per nucleus. In other words, the cross section per particle is equal to the observed efficiency of the bombardment reaction divided by the number of target particles per unit area.

This nuclear cross-section varies from reaction to reaction. However, experimental values usually range from 10^{-27} to 10^{-24} square centimeters per nucleus.

The American physicists Holloway and Baker, in 1942, proposed a code word for the unit of cross section. This unit of cross section was taken at 10^{-24} square centimeters, and humorously coded "a barn" because having a cross-section target of 10^{-24} square

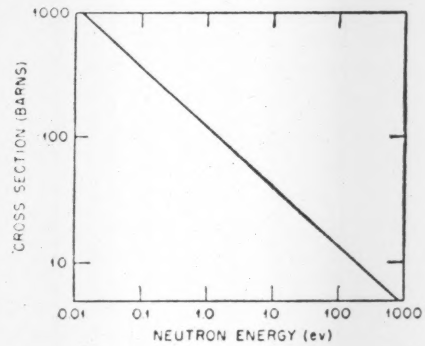

FIG. 5. NUCLEAR CROSS-SECTION for neutron capture by boron decreases uniformly as particle speed increases.

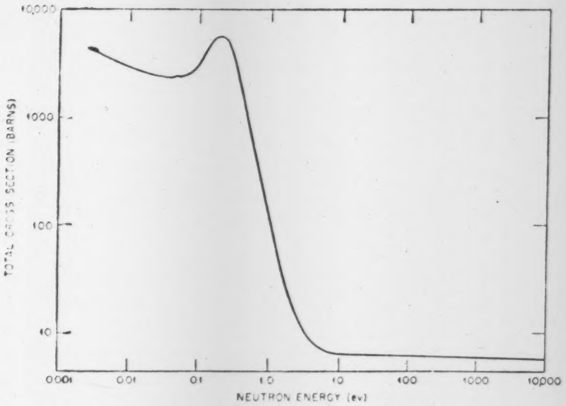

FIG. 6. NUCLEAR CROSS-SECTION for neutron capture by cadium 113 shows resonant peak when particle speed has energy of about 0.5 ev.

centimeters for nuclear processes is like shooting at the broad side of a barn. Actual cross-sections range from 10^{-8} (or less) to 10^4 barns for different reactions.

It must be emphasized that the cross section is not a single distinguishable physical property of an atom. like the section modulus of a beam. It is a highly qualified concept, applying to a particular type of situation.

The *absorption cross-section* is one of the most important cross sections because it tends to measure the capture of free neutrons by various elements. For example, the excessive capture of free neutrons by a reactor material can kill the possibility of a chain fission reaction. Materials with a high neutron capture cross-section, such as certain boron and hafnium isotopes, owe their usefulness as control-rod materials to this particular property.

Many elements, especially of atomic weight over 100, exhibit what are known as *resonant absorption peaks*. This means, in effect, that the absorption cross-section rises sharply for certain *values* of neutron energy. Some elements (such as cadmium and rhodium) have only one peak while others (such as gold) have two or more. These peaks can be found anywhere up to 10 ev and more.

U238 has a decisive peak at 5 ev, at which the cross section rises to several thousand barns. At such low neutron energies the capture reaction usually emits gamma energy.

Since the actual nuclear cross-section is only a few barns, the explanation for this unusual expansion of the target at resonance is of some interest. Briefly, the explanation is bound up with the thought that if a compound nucleus can be formed at or near the energy level of the incident neutron, the probability of neutron capture will be unusually high.

Basic Types of Fission Reactions

Figs. 5 and 6 illustrate resonant and nonresonant neutron capture in terms of capture cross-section.

In examining the variation of absorption cross-section with neutron velocity, the cross section for slow neutrons usually decreases with the velocity. This region is spoken of as the 1/v region and it is indefinite. Following the 1/v region many elements, especially of atomic mass over 100, exhibit resonant peak phenomena.

The foregoing diversions from the fission phenomenon has to do more with considerations of chain reactions than with neutron fission itself. Actually, the elements above tantalum are known to be capable of fission, but for an agglomerate of reasons uranium and thorium are at present the only "practical" materials. Further, thorium 232 is useful, not because it is a fissile material, but because the capture of a slow neutron in a (n, γ) reaction starts a reaction which after some days gives U233, a chain-reaction material:

$$\text{Th}232 + \text{n} \rightarrow \text{Th}233 \text{ (23 min)}$$
$$\text{Th}233 \rightarrow \text{Pa}233 \text{ (27.4 days)} + \beta$$
$$\text{Pa}233 \rightarrow \text{U}233 + \beta$$

U233 is an alpha emitter of 1.63×10^5 hr half-life.

Natural uranium in a pure form is an isotope mixture, 99.28% U238, 0.71% U235 and 0.006% U234 (for most purposes spoken of as 99.25% U238 and 0.75% U235).

U238 is not capable of conducting a chain reaction by itself because slow neutrons will not fission U238, although fast neutrons will. However, U238 will exhibit a preference for slow-neutron capture without fission.

When neutrons are absorbed by U238, the transuranium element plutonium is formed:

$$\text{U}238 \ (\text{n}, \gamma) \ \text{U}239$$
$$\text{U}239 \text{ (23.5m)} \rightarrow \text{N}_p239 + \beta$$
$$\text{N}_p239 \text{ (2.33d)} \rightarrow \text{Pu}239 + \beta$$

The end product (plutonium) is fissionable by fast and slow neutrons. When recovered by chemical separation it is a valuable prime fissile material. (When new useful fissile materials are produced faster than the prime is consumed this is called "breeding.")

On the other hand, U235 is fissioned both by slow and fast neutrons, and has a greater fission cross-section for the slow neutrons.

A reaction of pure natural uranium metal will not sustain itself because of the capture competition of the large percentage of U238 for the neutrons. Therefore, a pile of natural uranium must have its slow-neutron population enriched to the point where both the U238 and U235 can get enough. As the U235 cross-section for slow-neutron fission is large, a chain reaction can then take place with a reasonable slow-neutron population.

This limitation can be met by enriching the mixture in U235, but this means costly physical isotope separation.

However, power reactors that work with natural uranium alone can be achieved by increasing the slow-neutron population by conversion of the fast neutrons to slow.

This is done by taking advantage of a few light atom materials which have high elastic scattering cross-section and a small capture cross-section for the neutrons. (The atoms must be light because the fast neutrons have to lose energy by the recoil of the target. If the target atoms are large, like a marble striking a billiard ball, the marble rebounds without velocity loss.)

Moderators

Moderators can thermalize (slow down) neutrons without appreciable absorption. Of the few efficient moderators available, graphite and heavy water are outstanding. With them one can make a reactor of natural uranium.

With the exception of He, which is a gas, all other known moderators are less efficient and are used with enriched fuels.

The key to chain fission of an isotope mixture is, therefore, in the astonishing fact that the slow neutrons are more effective in producing fission than the fast neutrons.

These four main processes are taking place during fission and will determine the multiplication factor and the resultant success:

1. Complete escape of neutrons at the system boundaries.
2. Non-fission capture by U238 in the (n,γ) process.
3. Non-fission or parasitic capture by the moderator, impurities, fission products, etc.
4. Offsetting these losses, there is fission capture of both fast and slow neutrons by U235 and of fast neutrons by U238.

Pile Calculations

Fermi's method of calculation of the *multiplication factor* of the reactor is one of several methods. It is straightforward in the following simplified form, based on an ordinary uranium (U238 + 0.75% U235) pile.

Assume N fast neutrons are on hand. Before they have had a chance to slow down they will have caused a few U238 fissions and a smaller number of U235 fissions, because of the relatively low amount of U235 in the uranium. This slight increase in the free neutron population is stated by using a factor e (having a value frequency about 1.03) called the *fast-fission factor*.

As the Ne neutrons move through the system they encounter many elastic collisions with the graphite moderator, and inelastic collisions with the uranium, as a result of which their energy is rapidly brought down. It has been estimated that on the average 200 collisions with the moderator to one with a uranium nucleus occur. Since only 100 carbon collisions are necessary to slow the neutron to its thermal state, there is a high probability that every fast neutron introduced by fission will become thermalized below the 5-ev level at which resonance capture by U238 occurs. Nevertheless, a few will be captured so that a resonance escape probability factor p, less than unity, can be used to multiply Ne, giving Nep neutrons surviving. (p is factor determined by the reactor design and depends on the relative quantities of substances, the elastic scattering and capture cross-sections, etc.).

When the energy of the neutrons has been thermalized they diffuse in the moderator until they are either absorbed by the moderator or the uranium. The *thermal utilization factor* (f) is the fraction of slow neutrons that cause fission in U235.

Thus Nepf represents the neutrons involved in this process.

Finally, let m be the average number of fast neutrons produced for each thermal neutron absorbed by the U235. Then Nepfm is the number of fast neutrons produced by N at the start. Since N entered, the multiplication factor is

$$\mathrm{Nepfm/N = epfm}$$

It appears that the factor pf is really the only one under control. Thus, if there is a high ratio of moderator to uranium, p will be increased. However, f will be decreased because of a lower uranium proportion in the pile. The problem then is one of maximizing pf if the chain reaction is to be maintained.

One way of raising pf is to use enriched uranium; this will raise both p and f.

The geometry of the pile also can affect pf. Although the simplest arrangement would be an intimate mixture of the uranium and the moderator, there is an advantage to be gained (according to Fermi and Szilard) by building a lattice of large lumps of uranium or uranium oxide embedded in a mass of graphite. The resonance peak for the capture of neutrons by U238 is sharp, so that although the absorption cross-section is several thousand barns at resonance, it falls off rapidly when the neutron energy deviates from this value. Consequently, entering a uranium lump, neutrons close to the resonance value will be captured on the outside and the inside metal will be shielded. The decrease in the thermal utilization factor will be small so that pf will be increased.

One point was neglected in the previous discussion. The neutrons lost by boundary escape depend on the ratio of surface area to volume. Therefore, the system should be large, preferably in the form of a sphere. Although this is impractical in many cases, it is practical to surround the system with a *reflector*. A neutron reflector does not act like a mirror; it is made by using a substance of good moderator properties because the reflection process is efficient in slowing down fast neutrons which would otherwise escape.

Reactor Power

By arguments similar to the multiplication factor, the "power" of a nuclear reactor can be stated as

$$P = nvN\Delta V/3.1 \times 10^{10} \text{ watts}$$

where n is the average neutron density, number per cc; v is the average speed, so that nv is the average neutron flux; N is the number of fissionable (235) nuclei per cc; Δ is the fission cross-section; V is the reactor volume.

By introducing Avogadro's number into the foregoing, the "power" of a uranium reactor can be defined:

$$P = 2.5 \times 10^{-8} \text{ wnv watts}$$

where w is now the weight of U235 in pounds.

Thus, the heat produced in a given reactor of volume is proportional to the neutron flux or "mass flow" of neutrons, to the density of the U235, and the effective cross-section for the fission process. Note that this expression does not yield a reactor design basis. It simply states a power criterion.

Reactor Control

Calibrated ionization chambers containing boron trifluoride can indicate the neutron flux and thus the power directly. This reading is a prompt signal and can be used in a control cascade.

Delayed neutrons have been discussed. Although fission is almost instantaneous, mechanical control of the reactor multiplication factor is possible because of the delayed neutrons.

Assume that about 0.75% of the neutrons are delayed and that B is the fraction of neutrons which are delayed. Then (1—B) are prompt neutrons.

If the multiplication factor is K, then it can be regarded as consisting of two parts—that is, $K = kB + k_2 (1-B)$.

If the reactor control is adjusted so that $k_2 (1-B)$ is just equal to or less than unity, the chain reaction can be made to depend entirely on the delayed neutrons: Thus the transfer function of the operating reactor is a delayed-neutron function.

In some reactors the multiplication-factor control, owing to an excess of potential reactivity, can lose the delayed-neutron control edge which is depended on for control. When this happens the reactor is said to be "prompt critical" and is in trouble. In keeping with the peculiar language in this field "one dollar" of reactivity is defined as the reactivity excess required to make a reactor go "prompt critical."

Reactor Types, Present and Projected

All the projected reactors throughout the world as of 1955 have been classified* in two groups (Table 3).

TABLE 3—TEN BASIC REACTOR TYPES

GROUP ONE:	GROUP TWO:
1. Pressurized water	5. Heavy water
2. Boiling water	6. Graphite
3. Swimming pool	7. Sodium graphite
4. Homogeneous	8. Liquid metal cooled
	9. Liquid fuel
	10. Fast breeder

Types 1, 2 and 4 are used for power. All in group one use ordinary water as a moderator and must therefore use enriched uranium. They are all slow-neutron or thermal reactors.

The heavy-water reactors (5) use natural uranium as a fuel (with a few exceptions), and are thermal neutron reactors, mostly used for research and plutonium production.

The graphite reactors (6) are also used for research and Pu production, although the Canadians, Norwegians, British, Russians and French have electric power reactors of this type under way. They use natural uranium, enriched in a few cases.

The sodium graphite reactors (7) use sodium metal as a coolant. The two listed are power reactors.

The liquid metal cooled (8) are research reactors using intermediate speed neutrons.

The one liquid fuel reactor (9) is a power reactor using graphite and an amalgam of uranium and bismuth which fissions and is pumped through a cooler.

A most interesting type is the fast breeder reactor (10) which uses no moderator. The fuels range from enriched uranium to pure plutonium. Those listed are power reactors. The core of U235 or plutonium will be surrounded by an ordinary uranium blanket in which plutonium will be bred. By using thorium 232 in the blanket, U233 also will be produced.

Three loose generalizations relating to power reactor types are possible:

First, the simplest types are the least efficient. Increase in efficiency seems to be bought by complexity.

Second, the least efficient types often have an edge on the more efficient types in the matter of fuel throughput. Thus, a fuel throughput factor (corresponding to the number of times the fuel has to be reprocessed before one charge is completely consumed) is obviously a vital economic factor, and may be better in a simple reactor than in a complex one.

Third, countries which have no isotope separation prospects are taking the "plute route."—in other words, the use of natural uranium and plutonium production. American practice, however, makes use of enriched fuels and relatively complicated cycles.

Acknowledgement

The figures and illustrations are from the book "*Sourcebook on Atomic Energy*," by Samuel Glasstone, copyright AEC, published by D. Van Nostrand, 1958.

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*Nuclear Reactor Data, Published by Raytheon Mfg. Co., Waltham, Mass., 1955.

TABLE 1—COMMON RADIATION TYPES

TYPE	MASS	CHARGE	ENERGY, Mev	PRIMARY INTERACTIONS	BASIC DETECTORS
α	He^{++}	++	5-10	IONIZATION	IONIZATION CHAMBER PROPORTIONAL COUNTER
$\beta\pm$	e^-	±	0-4	IONIZATION, RADIATION	GEIGER COUNTER PROPORTIONAL COUNTER
γ	0	0	0-4	PHOTOELECTRIC, COMPTON, PAIR PRODUCTION	SCINTILLATION COUNTER
n	$\sim H^+$	0	0→	ELASTIC COLLISIONS	BF_3 PROPORTIONAL COUNTER FISSION ION CHAMBER COMPENSATED ION CHAMBER UNCOMPENSATED ION CHAMBER
x	0	0	0→0.1	PHOTOELECTRIC, COMPTON	PROPORTIONAL COUNTER SCINTILLATION COUNTER

TABLE 2—COMMON RADIATION DETECTORS

DETETECTOR	SENSITIVE VOLUME	SPEED, Sec	MULTIPLICATION	ENERGY RESPONCE
IONIZATION CHAMBER	GAS	10^{-6} to 10^{-3}	1	LINEAR
PROPORTIONAL COUNTER	GAS	10^{-6}	10^{3}	LINEAR
GEIGER COUNTER	GAS	10^{-4}	10^{7}	SATURATED NON-LINEAR
SCINTILLATION COUNTER	SOLID (LIQUID)	10^{-9} to 10^{-6}	10^{6}	LINEAR

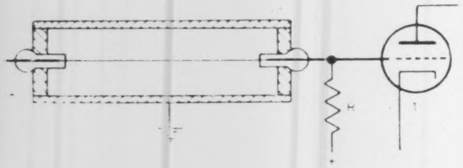
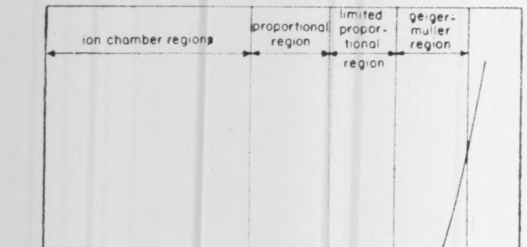


FIG. 1. IONIZATION CHAMBER connected to electrometer tube. Gas chamber can function as ion chamber, proportional counter, or Geiger counter, depending on voltage applied across chamber.

FIG. 2. VOLTAGE BETWEEN ELECTRODES causes gas chamber to operate either as ionization chamber, proportional counter, or Geiger counter.



Trends in

JAMES B. WILLIAMS

Baird-Atomic, Inc.

MANY BASIC UNITS of matter and energy are known (proton, neutrino, meson, graviton, etc.) but the most common types of radiation are *alpha* and *beta* particles and *gamma rays* (Table 1). The alpha particle is simply the nucleus of a completely ionized helium atom; the beta particle is an electron of either polarity (a positive electron is a positron); the gamma ray is simply a photon of electromagnetic energy, differing from radio waves, light, and x-rays only in its shorter wavelength (and hence higher energy).

These radiations are emitted from excited nuclei according to certain selection rules which determine the emission probability (and hence the half-life) as well as the type of transition (or disintegration) that the atom undergoes. Radiation occurs when the electric or electromagnetic forces inside the nuclei are out of balance. Sometimes the result is the emission of an alpha or beta particle which changes the mass (energy) and the charge of the nucleus and thus yields a new element; sometimes the result is the simple emission of a gamma-ray photon.

In recent years it has become necessary to deal with *neutrons*. These are basic nuclear particles similar in size to the hydrogen nucleus but with no charge. Neutrons are commonly found only as products of interactions between basic radiations and nuclei. Because of their electrical neutrality, neutrons interact primarily with atomic nuclei.

DETECTORS

Table 2 summarizes the properties of the most common radiation detectors. The ionization chamber, the proportional counter and the Geiger counter are simply gas-filled chambers with two electrodes (Fig. 1). The only difference between types of operation is in the voltage applied between the electrodes.

The passage of radiation through the gas in any gas-chamber type of detector can produce an "event" —either the ionization or excitation of some of the gas molecules in the chamber.

Radiations represent *minute* quantities of mass and energy, and no direct method of detection and an-

Radiation Instrumentation

A résumé of the operation of basic radiation detectors and instruments, the improved circuitry incorporated in the newer equipments, and trends in the field.

alysis can be used in their measurement. Secondary effects, such as ionization and excitation, must be used. These secondary effects must be amplified by a factor of one million or more before they are of measurable magnitude. Alhough detectors have different inherent multiplication factors (internal gain), to achieve an over-all gain of the order of one million, most detectors must have supplementary external electronic amplification.

Fig. 2 shows the differences in operation of ionization chambers, proportional counters, and Geiger counters. In Fig. 2, charge per pulse is plotted versus voltage applied between anode and cathode. As the voltage between these two elements is increased, the electrons and positive ions created by the passage of a charged particle through the gas separate and migrate to the anode and cathode respectively.

The charge per pulse in the *ion-chamber region* increases until the effect of "saturation" occurs—that is, until all ions from each event are collected. From then on, there is a flat region.

Fig. 2 shows two curves, the lower from a beta particle and the upper from an alpha particle. The charge per pulse is greater for the alpha particle in the ion-chamber region because of the greater specific ionization of the alpha particle. As long as the gain within the counter gas is unity, the detector is in the ion-chamber region. However, as soon as gas multiplication occurs, the instrument is said to be in the *proportional region*. Where the alpha and beta curves coincide, the *Geiger region* begins. In this region the *type* of ionizing radiation no longer influences the charge collected per pulse. Ion chambers, proportional counter tubes, and Geiger-Mueller tubes are available in many sizes and shapes.

Ionization Chambers

In an ionization chamber (Fig. 1) the ion current is a measure of the character and intensity of the radiation. The gas amplification within the chamber is unity; hence the signal from the ion chamber requires considerable amplification before it can be recorded. The anode is generally from 1/10 to 1/100 the diameter of the cathode and is coaxial with it. A typical voltage across the electrodes is 100 volts.

Ion chambers are used widely as instruments in health work because they provide a direct measure of the ionization formed by the radiation. This aspect of ion chambers is important because the damage to body tissue by radiation is, to a first approximation, proportional to the number of ions formed in the tissue cell.

A widely used type of ion chamber is of the personnel monitoring type. This instrument, the size of a fountain pen, is called a pocket meter. It is essentially a cylindrical capacitor of high leakage resistance charged with a potential between 20 and 200 volts. Exposure to radiation reduces this charge, and the amount of reduction is correlated to the radiation (measured in roentgens).

Proportional Counter

In this instrument the voltage between the electrodes is adjusted so that the output pulse is proportional to the number of ions produced in the gas by the primary ionizing particle. As the gas amplification within the counter tube is about 10^3, the electronic amplification necessary for recording the signal is less than for the ion chamber.

The anode is on the order of 1/1000″ and the cathode is usually coaxial with it. A potential of, let us say, 3000 volts is placed across the electrode system, establishing an electric field.

When an ionizing particle passes through the gas, the electrons liberated set up a chain of multiple ionizations (the Townsend avalanche). The result is an output signal that may be one thousand times that obtained from a conventional ion chamber. Since the signal is proportional to the number of ions formed by the radiation, discrimination between various types of radiation can be achieved by proper circuitry. Moreover, the speed of operation of a proportional counter is limited primarily by its electronic circuit. Owing to these advantages the proportional counter is used widely in quantitative laboratory studies.

Geiger Counter

In a Geiger-Mueller counter, or Geiger counter, the ionizing event produces ions in the gas which in turn create between the electrodes a uniform voltage pulse

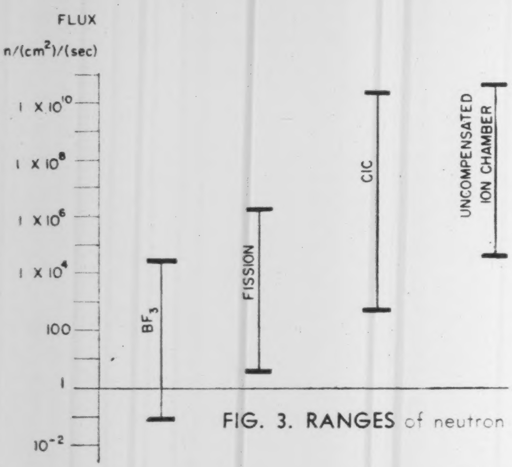


FIG. 3. RANGES of neutron detectors.

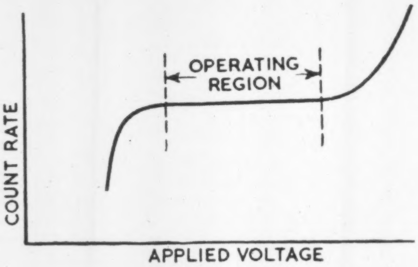


FIG. 4. GEIGER COUNTER OPERATES in the plateau region. Counting rate represents frequency of radiation events, and is insensitive to level of high voltage or to energy of incident pulse.

independent of the number of ions formed by the initial event. The signal usually is one thousand times greater than that from a proportional counter, being on the order of a few volts. Consequently, a rather simple recording circuit is required. As a result, this type of counter is in frequent use. It has, however, certain disadvantages—(1) it cannot readily discriminate between different types of radiation, (2) it cannot give a linear response versus energy, (3) its operation is some one hundred times slower than that of a proportional counter. Owing to its initial cost and other advantages, however, the Geiger counter is today the most widely used sensing unit.

Geiger counters, like all gas-chamber-type detectors, are relatively insensitive to gamma rays and have about one percent gamma ray efficiency versus almost 100% efficiency for energetic beta radiation.

Scintillation Counter

Table 2 lists a scintillation counter. This is simply a crystal that fluoresces, or flashes, when struck by an incident particle or photon. The flashes are amplified by a photomultiplier tube; the signal is further amplified and then counted. Like the proportional counter the scintillation counter has a linear response.

Neutron Detectors

In reactor control the neutron flux must be measured and controlled. As shown in Table 1, the detectors for neutron flux include the BF_3 proportional counter, the fission ion chamber, the compensated ion chamber, and the uncompensated ion chamber. All of these are gas-filled ion chambers, but are made sensitive to neutrons by use of fillings or coatings that interact with the neutrons to produce fission fragments or alpha particles that in turn produce the output pulses.

The BF_3 proportional counter is used to cover the neutron thermal flux range from about 1.0 to 10^5 neutrons/cm² sec (Fig. 3). A typical chamber is about 12″ long and 1″ in diameter and filled with 96% B^{10}-enriched BF_3 gas at a pressure of about 55-cm Hg. It has a sensitivity of 4.5 counts/neutron/cm²/sec at 2000 volts dc across the chamber, and a gas amplification factor of 500 at this voltage. Since neutrons are uncharged, ionization is caused by secondary effects—that is, a neutron and a B^{10} molecule interact to produce a lithium nucleus and an alpha particle with kinetic energy.

This exothermic nuclear reaction produces about 2.5 Mev. The rapidly traveling alpha particles (helium nuclei) and lithium nuclei cause formation of ion pairs in the chamber. A 2000-v electric field separates the electrons and the residual ions; a voltage pulse of a few millivolts with a 1-microsecond rise time appears between the electrodes. The large amounts of gamma radiation present also cause pulses from incident photons due to the Compton effect. However, the resulting pulse heights due to gamma are generally small enough (in the microvolt region) that they can be biased out by discriminator circuits in the linear amplifier.

The *fission chamber* is typically 2″ in diameter and 12″ long and has an electrode coated with uranium oxide enriched with the U^{235} isotope. One atmosphere of nitrogen-argon gas is used for filling gas, which is ionized by fission fragments, producing pulses. As shown in Fig. 3, it can be used to span the start-up range of neutron flux, and is generally used in the range from 10^2 to 10^6 neutrons/cm²/sec because of its lower sensitivity of 0.7 count/neutron/cm². One advantage of this type of counter is its ability to operate in gamma fluxes of 10^{10} photons/cm²/sec without loss in sensitivity.

Compensated ionization chambers are generally used to span about six decades of the intermediate and power range from approximately 5×10^3 to 2×10^{10} neutrons/cm²/sec with a sensitivity of 2×10^{-14} ampere/neutron/cm²/sec. In this type of chamber, compensation for incident gamma radiation is performed in the chamber itself. Approximately 24″ long and 3″ in diameter the chamber is composed essentially of two ion chambers combined into one arranged as three nested cups separated by spacers.

The outside or distal cup is connected to an 800-v positive d-c source and the inside or proximal cup

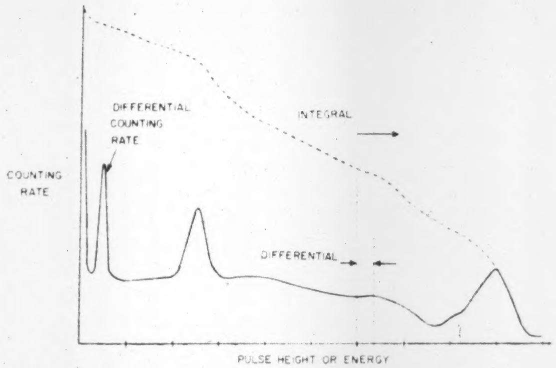


FIG. 5. COUNTING RATE IS A FUNCTION of the energy of the incident radiation in an ionization chamber or proportional counter. Dotted curve shows total (integral) counting rate (all counts above a fixed pulse height); differential counting rate is the count only of pulses between two given energy levels.

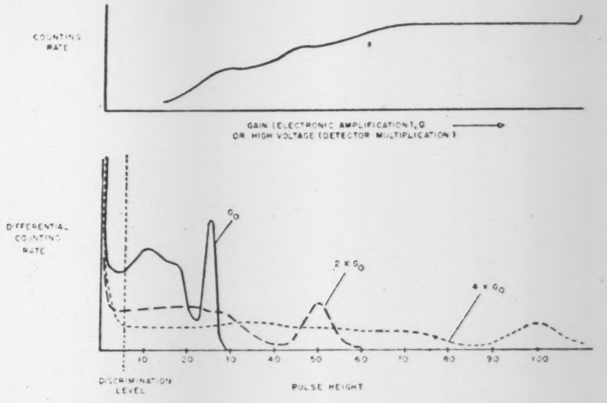


FIG. 6. COUNTING RATE CAN BE MADE insensitive to gain, or one or more discrimination thresholds introduced to select and channel events of different energy (voltage) levels.

connected to a source of negative voltage of approximately 100-v dc. The signal lead is connected to the center cup. The inside surface of the distal cup and the outside of the center cup are coated with B^{10}-enriched Boron. This volume is sensitive to neutrons and gamma. The other surfaces are uncoated and thus, sensitive to gamma only. All volumes are filled with 1 atmosphere of nitrogen. Owing to the opposite polarities of the voltages on the cups, the current signal produced by incident gamma radiation can be largely cancelled out, and only the current due to the neutron flux measured.

Uncompensated ionization chambers are boron lined and similar to the compensated ionization chamber without gamma compensation provisions (because only two cups are used). Gamma compensation is not felt to be necessary at high power levels because here the ratio of gamma neutron flux is small, usually well under 10%. They are used as primary elements on the level safety channels and cover the upper decades between 5 x 10^5 to 2 x 10^{10} neutrons/cm^2/sec and up.

Plateau Operation

Simple counting applications are concerned mainly with the routine assay of samples where the radiation information presented to the detector is always of the same kind and differs only in degree, or counting rate intensity. Here the desired system characteristic is a plateau, a region where the counting rate does not vary appreciably with changes in other parameters, such as the applied voltage (and hence detector multiplication). Such a characteristic is typified by the Geiger-counter plateau (Fig. 4). The change of counting *rate* with increasing voltage is very small.

The multiplication within a Geiger tube is so high that the entire tube is paralyzed during a pulse. Thus pulses are generated of the same amplitude regardless of the amount of energy initially dissipated in the tube. Although the gas multiplication of the tube actually increases with the high voltage and results in increasing pulse height, once the constant amplitude pulses exceed the discrimination level, all will be counted and essentially no more added as the high voltage is increased. This limiting is due to the intrinsic behavior of the Geiger tube, and is the reason it is not capable of differentiating between the *energies* of radiation which trigger it. The Geiger electronic system requires only an elementary counting circuit because the detector provides pulses of sufficient amplitude; it also can have slow response because Geiger-tube pulses are seldom narrower than 100 microseconds.

Fig. 5 shows that the counting rate of an ionization chamber or proportional counter (and also a scintillation counter) does depend on pulse height, or energy of incident radiation.

It is not generally appreciated that plateaus can be obtained from ionization counters, proportional counters, and scintillation counters, as well as from Geiger tubes. This can be achieved merely by positioning the spectrum so that virtually all of the pulses lie above the discrimination level. Thus, any increase in electronic system gain cannot change the counting rate much because essentially all of the pulses are being counted (Fig. 6). Plateau production sounds simple, but the detector generates a wide dynamic range of pulse heights. If the discrimination is placed at a few volts, many arriving pulses exceed this value by a factor of ten or more. Increasing system gain, either by increasing the electronic amplification or the detector multiplication, can increase this factor to 1,000 or more.

This overloading places a heavy burden on the electronic system. If the system can recover from these impacts quickly without introducing spurious counts, this operation yields an elegant electronic plateau. A typical plateau is shown in the top curve of Fig. 6. Note the bumps on the lower curve as one peak after another is added to the counting rate by increasing the gain.

THE ELECTRONIC SYSTEM

The detector must be selected for the radiation type and range desired, and the amplifier then specified to get sufficient amplification so that the number of incident particles (or radiation) can be counted.

Pulse-Height Discrimination

Before counting the detected and amplified events, a stage must be interposed (Fig. 7) that selects only those signals caused by the type of radiation that is to be counted. This discriminating is done either by a discriminator or an analyzer. The *pulse-height selector* (*discriminator*), is a simple integral type that gives a constant output pulse whenever the input pulses exceeds some preset voltage level. The pulse-height *analyzer* (differential discriminator) comprises one or many channels that deliver an output pulse whenever the input pulse falls between two prescribed voltage levels. This latter type is useful for analysis of energy or amplitude distributions as in identification or separation of different radioactivity sources.

The output of pulse-height selectors or analyzers are invariably constant in amplitude, the presence of an output indicating that a pulse has been received which satisfies certain pulse-height requirements. The output pulses are then fed into some kind of totalizer, scaler, or ratemeter for counting and recording. Some systems merely count while others are designed for energy analysis.

System Requirements for Radiation Analysis

Radiation analysis requires scrupulous preservation of spectral information and long-term system stability. Typical applications use linear detectors for isotope identification and purity analysis, multiple tracer studies, and medical or physical experimentation such as scattering effects. The linear detectors commonly used today are the gas-flow proportional counter and the scintillator-photomultiplier assembly.

The response speed of these fast linear detectors is of the order of microseconds, or even faster, and the amplifiers must have a fast rise time to respond to an incoming voltage pulse. The amplitude of the relatively flat top of the pulse is the information desired, so the amplifier must be able to faithfully reproduce low frequencies as well. Thus in atomic work the electronics must be wideband, or "video."

The last and most important requirement is that the instrument be stable in its characteristics and reliable over long periods of time.

Thus, in review, the amplifier must be wideband and linear, fast and non-overloading, and stable and reliable. These properties cannot all be optimized simultaneously. For example, speed implies the switching of rather large currents in short times (requiring "high-gm" or "hot" vacuum tubes), which is obtained only at the expense of long-term reliability.

The analyzer or discriminator has the same general requirements because it must respond to each input pulse. An additional requirement of the analyzer is that it be able to make separate, accurate decisions about pulses which occur close together in time. This property is called the *resolving time*.

Register

The register receives the signal from the discriminator. It can consist of a totalizer, such as an electronic scaler or mechanical counter, or it can be a ratemeter, which indicates the average rate of pulses. The general characteristics of the register are considerably less stringent than those of the other instruments in the system because it only has to count pulses of constant amplitude.

Amplifier Circuitry

The amplifier usually is separated into a preamplifier at the detector and a high-gain amplifier at the data-handling site. The preamplifier must be compatible with subsequent circuitry and reduce the impedance level from the high value at the detector (about 10^8 ohms) to a low value (about 100 ohms) to drive the long cable without signal loss and distortion.

Historically the simple cathode follower has done this preamplification, but has seen a significant modification recently (Fig. 8). The cathode resistor has been replaced by a second vacuum tube used as a constant-current generator. The addition of the feedback path has made an important improvement in linearity. This improved circuit outperforms the older circuits and is essential for analytic measurements.

The amplifier also has undergone extensive changes, the most significant being a result of the non-overloading requirement. The amplifier must limit the size of superpulses, and recover quickly in order not to distort subsequent pulses.

The most significant change followed a realization that high counting rates of very large pulses tend to shift average d-c levels and, hence, the operating points of each stage. This brought a radical departure from earlier, unsuccessful attempts to keep the pulse from crossing the baseline. The new concept involves double-differentiation which inverts the pulse in polarity to turn the amplifier off for a certain short length of time. This restricts the time duration of the pulse and insures rapid recovery. Also, carrying through the amplifier a biphasic pulse which has essentially the same area above as below the baseline (Fig. 9) prevents a d-c shift in operating points.

Other tricks are used. One is the application of limiters (usually diodes) to "clamp" or restrict the amplitude of pulses; another is the use of paired stages where a large incident pulse can, at most, turn off one stage to switch a restricted amount of current into the next stage (Fig. 10). This circuit has the added advantage that it always can be made to yield a negative pulse to following stages. This prevents grid current from flowing, which would charge coupling capacitors and cause subsequent undershoots and overshoots.

Pump circuits with current reservoirs help achieve high linearity at high pulse amplitudes by keeping one or more circuits in a high-current stand-by condition able to supply current on demand to boost the signal output.

An all-out effort for stability and reliability has employed all the tricks of conventional signal feedback (Fig. 11). A new feature is low-frequency or d-c feedback for stabilizing the gm and d-c operating points of critical stages. These techniques and large derating factors in power-dissipating components provide significant improvements in reliability.

Pulse-Height-Analyzer Circuitry

Each major government laboratory has designed its own special multi-channel pulse-height analyzer, and most are available commercially. The general principle employed (in most of those with one-hundred-channels or more) is amplitude-to-time conversion. This involves stretching the input pulse and simultaneously triggering a voltage-ramp generator and a clock-pulse generator feeding a scaler (Fig. 12). When the ramp voltage equals the input pulse level, the clock is turned off and the number of pulses in the scaler identifies the particular memory storage channel, to which is added one count or digit.

Fig. 13 shows a new discriminator circuit which successively and rapidly *subtracts* precise voltage steps from the stretched input pulses. These steps are counted as described previously.

The application of nonlinear feedback to discriminator trigger circuits is a significant new development. (Fig. 14).

Scaler Developments

The developments in scalers have depended primarily on the state-of-the-art of components. Early models used the binary scale-of-two flip-flop. Next came the feedback binary decade. These instruments depended on hard-tube components and suffered from their inherent lack of reliability.

The single-element decade tubes developed recently, such as the high-vacuum beam-switching tube, have good reliability and high speed. Another, the cold-cathode glow-transfer "Dekatron" tube, has long life and provides direct visual readout.

The Future

We can predict that the future will show:

(1) increased use of data handling devices, such as automatic read-out and print-out.

(2) considerable automatic programming of complex systems, and of complete laboratories.

(3) a strong emphasis on low-background systems: the increasing use of radioisotopes in medicine and industry will demand measurements an order of magnitude or two lower than the levels in common use today.

(4) totally electronic systems that depart from mechanical registers, timers, and printers and use solid-state devices, moving into the millimicrosecond area for much analytic work.

(5) increasing use of nonlinear feedback.

Acknowledgement

Figs. 1 and 2 are from the book *Nuclear Reactors for Industry and Research*, edited by E. Wakefield, Instruments Publishing Co.

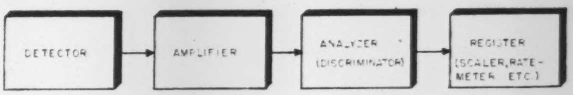


FIG. 7. BLOCK DIAGRAM of radiation-sensing system.

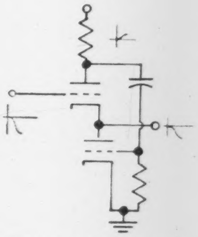


FIG. 8. STACKED cathode follower.

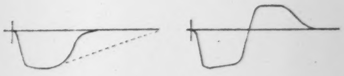


FIG. 9. D-C PULSE (left) is made to swing back across baseline by double differentiation (right) for fast recovery. Equal areas above and below baseline minimize shift in tube operating point.

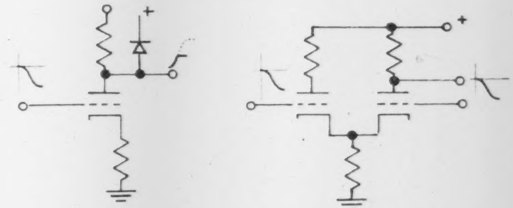


FIG. 10. DIODE LIMITING (left) and long-tail pair (right) are used to help amplifiers recover quickly.

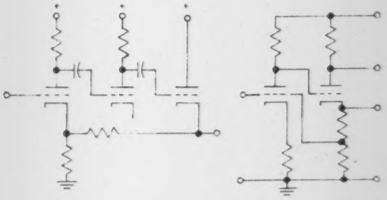


FIG. 11. FEEDBACK (left) and d-c operating-point stabilization (right) improve stability.

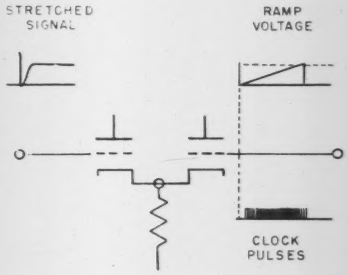


FIG. 12. TIME for ramp signal to rise to level of pulse signal identifies energy of signal.

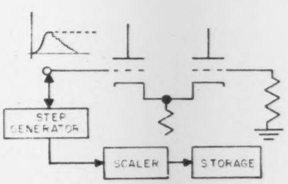


FIG. 13. DISCRIMINATOR uses subtraction technique.

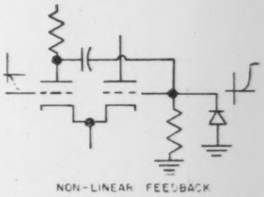


FIG. 14. DIODE provides nonlinear feedback for reliable triggering.

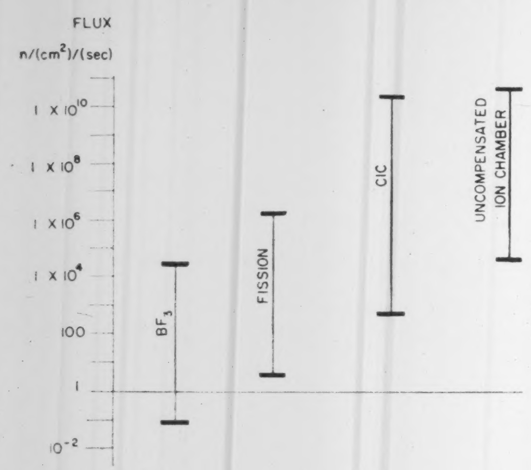


FIG. 1. RANGES of various primary elements for radiation detection.

Control of a nuclear reactor includes overlapping control channels for startup, intermediate power, and full power operation. Here is a survey of reactor kinetics, detector ranges, and instrumentation of low-power test and medium-power boiling-water reactors.

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Leeds & Northrup Co.

REACTOR CONTROL

CONTROL of neutron flux level (expressed as neutrons/cm²/sec) and control of the rate of change of this flux with respect to time (defined as "period") are two key factors in control and safety systems for heterogeneous reactors.

Reactor Kinetic Equations

The power of a nuclear reactor is practically proportional to the neutron flux. The chain reaction condition is that each uranium nucleus capturing a neutron and undergoing fission must ultimately yield a minimum of one neutron which also causes fission. The effective multiplication factor (K_{eff}) for a reactor is defined as the ratio of the number of neutrons in any one generation to the number of neutrons in the immediately preceding generation.

$$K_{eff} = \text{production}/(\text{absorption} + \text{leakage}) \qquad (1)$$

Control of the reactor system requires control of the effective multiplication factor (K_{eff}). If K_{eff} is less than one, the reactor is subcritical and the reactor power level will decrease. If K_{eff} is greater than one, the reactor becomes supercritical and the power increases continually.

Reactivity

Reactivity for a specific reactor can be defined as:

$$P = (K_{eff} - 1)/K_{eff} = \delta K \qquad (2)$$

Mean Effective Neutron Lifetime

The average time between successive neutron generations in a reactor is defined as the *mean effective neutron lifetime* (L^*). If there are n neutrons per cc initially in the core of a reactor, then the increase in each generation is approximately $n\,\delta K$. Hence L^*, the effective time between succeeding generations, becomes:

$$dn/dt = n\delta K/L^* \qquad (3)$$

After integration:

$$n = n_0 e^{\delta K t/L^*} \qquad (4)$$

where n_0 is the number of neutrons/cm³ initially, and n is the number after some time. As can be seen, the number of neutrons (neutron flux) can raise exponentially with time *if* the effective multiplication factor is greater than unity.

Period

Period is defined as:

$$T = L^*/\delta K \text{ seconds} \qquad (5)$$

Substituting equation (5) in equation (4) gives n in terms of period:

$$n = n_0 e^{t/T} \qquad (6)$$

Thus period is the "e folding time," or the time in seconds necessary for the reactor flux density or power to increase or decrease 2.718 times. A "period" will develop whenever K_{eff} is greater or less than unity.

It has been assumed in the above equation that all the neutrons created were given off instantly with a lifetime of L^*. Fortunately, about 0.76% of the neutrons emitted are delayed (with a mean delay time in the order of 0.1 sec for U^{235}). As the mean lifetime of the prompt emission is about 10^{-4} sec for a water- or graphite-moderated thermal reactor, the delayed neutron emission from the fission products makes the reactor controllable. If K_{eff} is allowed to exceed 1.0076, the reactor becomes critical on prompt neutrons alone, and the power level rises very rapidly because the period is now determined by the prompt lifetime rather than the delayed lifetime. This condition is called

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Presented at Seventh annual Symposium of the Philadelphia Section ISA on "Instrumentation in the Nuclear Age," Nov. 7, 1957.

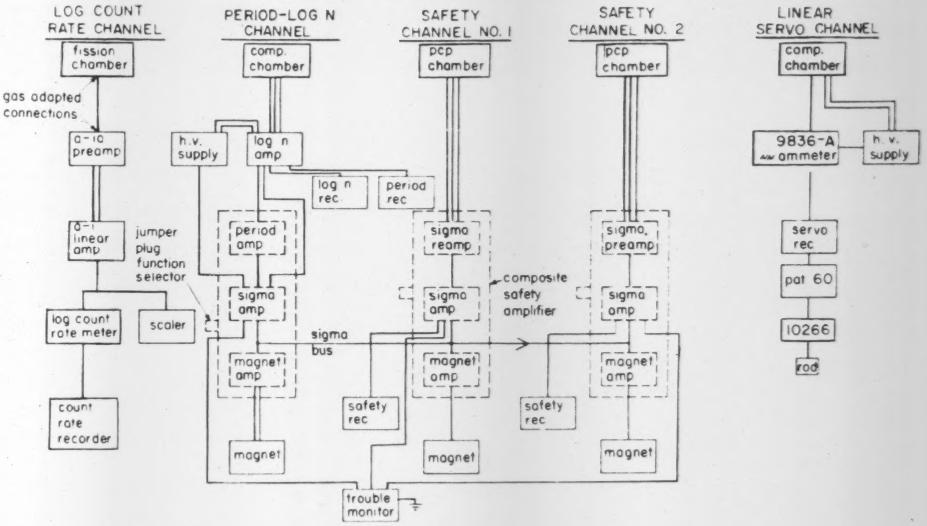

LOG COUNT RATE CHANNEL
PERIOD-LOG N CHANNEL
SAFETY CHANNEL NO. 1
SAFETY CHANNEL NO. 2
LINEAR SERVO CHANNEL
fission chamber
comp. chamber
pcp chamber
pcp chamber
comp. chamber
gas adapted connections
a-10 preamp
h.v. supply
log n amp
9836-A ammeter
h.v. supply
log n rec
period rec
a-1 linear amp
jumper plug function selector
period amp
sigma reamp
sigma, preamp
servo rec
composite safety amplifier
sigma amp
sigma amp
sigma amp
pot 60
log count rate meter
scaler
sigma bus
10266
magnet amp
magnet amp
magnet amp
rod
count rate recorder
safety rec
safety rec
magnet
magnet
magnet
trouble monitor

FIG. 2. CONTROL SYSTEM for a low-power swimming-pool reactor. Recorders include count rate recorder, log-N recorder, period recorder, and linear (servo) recorder.

"prompt critical" and the amount of positive reactivity necessary to make a reactor prompt critical is termed *one dollar*.

Because of the delayed neutron effect, it can be shown that an asymptotic approximation to the amplitude of the appropriate transfer function describes the reactor as an integrator with decreased gain at lower frequencies[1]. Using transfer functions to describe a reactor as a control loop element has been used many times in control design since Harrer, et al.[2] outlined the results of a frequency response study on the CP2 reactor (sinusoidal disturbances in δK were produced by oscillating the control rod with small amplitude and varying the frequency of this oscillation; neutron flux density was plotted versus the frequency of the δK disturbance).

Primary Elements

All reactor control and safety systems are based on measurements of the neutron flux density near the core. These measurements are made by various types of ionization chambers, and must be made as rapidly and with as much precision as possible. As absolute reliability is not possible, measurements are duplicated. Unfortunately, no one type of ion chamber has a sensitivity-vs-saturation characteristic that can span the whole neutron flux spectrum from source strength (generally about 0.5 neutron/cm^2/sec at the chamber) to high power (around 10^{10} neutrons/cm^2/sec).

Generally a *BF_3 proportional counter* is used to detect neutrons in the thermal flux range from about 10^{-1} to 10^5 neutrons/cm^2/sec (Fig. 1).

A high-sensitivity *fission counter* also can be used to span the startup range of neutron flux and is generally used in the range from 10 to 10^6 neutrons/cm^2/sec per second because of its lower sensitivity of 0.7 count/neutron/cm^2 for a background counting rate of 5 cps. One advantage of this type of counter is its ability to operate in gamma fluxes of 10^{10} photons/cm^2/sec without appreciable loss in sensitivity.

Compensated ionization chambers are generally used to span about six decades of the intermediate and power range from approximately 10^3 to above 10^{10} neutrons/cm^2/sec with a sensitivity of 2×10^{-14} amperes/neutron/cm^2/sec. In this type of continuous output chamber, compensation for incident gamma radiation is performed in the chamber itself.

Uncompensated ionization chambers are used as primary elements on the level safety channels, and cover the upper decades between 10^5 to above 10^{10} neutrons/cm^2/sec and up. These chambers are boron lined and similar to the compensated ionization chamber without gamma compensation provisions (as only two cups are used). Gamma compensation is not felt to be necessary at high power levels because here the ratio of gamma/neutron flux is small, usually well under 10%.

RESEARCH REACTOR SYSTEMS

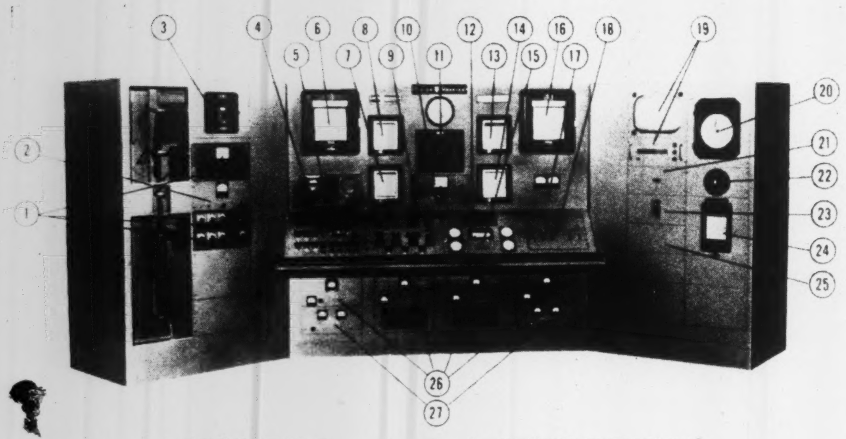
Fig. 2 shows an early type of system designed for a low-power 100-kw swimming-pool research reactor.

Log Count Rate Channel

For the startup channel, pulses from either a BF_3 or fission counter are preamplified in an amplifier located generally not more than 40′ from the chamber. This 3-stage preamplifier has a gain of 30 and a cathode follower stage which matches the input impedance of the linear amplifier.

Linear Amplifier

The next device in the channel is the linear amplifier. It is on the control panel and is designed to accept voltage pulses of short duration from the linear preamplifier and deliver them at proper impedance to the counting instruments. The voltage pulses at the input to the amplifier have a fast rise time, but decay



1 - Area Radiation Monitor
2 - Log Count Rate Meter
3 - Coolant Conductivity Controller
4 - Start-Stop Station Panel
5 - Binary Scaler
6 - Multi-point Area Radiation Recorder
7 - Log Count Rate Recorder
8 - Period Recorder
9 - Rod Positioning Panel
10 - Micromicroammeter
11 - Annunciator
12 - Inter-communication Set
13 - Log N Recorder
14 - Linear Level Recorder
15 - Rod Position Indicating System
16 - Multi-Point Process Temperature Recorder
17 - Log N Amplifier
18 - Television Camera Control Panel
19 - Television Monitor
20 - Coolant Flow Recorder
21 - Servo Reference Voltage Supply
22 - Coolant Pump Vacuum Indicator
23 - "Coincidence Scram" Selector
24 - Storage and Waste Tank Level Indicator
25 - "Trouble" Monitor
26 - Level and Period Safety Amplifiers
27 - Compensated Ion - Chamber Power Supplier

FIG. 3. CONTROL PANEL for a Livermore Type pool reactor. Recorders for control purposes include log count rate recorder (7), period recorder (8), log N recorder (13), and linear level recorder (14). Similar types of consoles have been supplied for the Danish, the Sao Paulo and Hamburg research reactors.

with the time constant of the preamplifier. A differentiator in the circuit assures that the amplified pulse follows the wave shape of the incoming pulse. A feedback loop is used to adjust the rise-time of the amplifier and to make the transient time response satisfactory in the wide-bandwidth position. A regulated power-supply supplies the preamplifier and the main amplifier: it also provides anode voltage for operation of a fission chamber. (When using a BF_3 counter, a separate high-voltage power supply is necessary to furnish the polarizing voltage of several thousand volts). As the linear amplifier also contains a discriminator circuit that rejects pulses of low amplitude formed as the result of incident gamma flux at the pulse chamber, only the pulses due to neutrons are amplified and counted in the succeeding stages.

A log count rate meter is used to measure the average rate of the series of pulses from the linear amplifier.

The count rate is displayed on a log count rate recorder calibrated from 1 to 10,000 cps (four decades). A low-level differentiating network can be added to the LCRM to give *period indications*. This period indication is of great value because startup is the reactor's most critical mode. However, due to the statistical variations mentioned previously, this period indication is not too reliable when counting rates are under 1000 cps. A better indication of period can be obtained from the average slope of the curve on the log count rate recorder, or measuring the time in seconds for the linear recorder pen to move from 2.7 to 7.4 on the scale, or on the low range of the micro-microammeter (Fig. 3).

Another output from the linear amplifier can be sent to the scaler, or electronic counter, as shown in Fig. 2. Scalers indicate the total number of pulses received and are useful in cold reactor startups and critical experiments. There are two types of scalers—binary and decade. The decade scaler is easy to read but this advantage is offset by the greater inherent reliability and high speed of the binary type. For reactor operation, where reliability is of prime importance, the binary scaler is recommended.

The scalers have various scale factors and the most convenient factor is the one in which the speed of resolution of the scaler is not greatly limited by the speed of operation of the register. A scale of 4096 with 1-microsecond resolution is probably an optimum choice.

It is the usual practice, for safety, to have two startup channels, one of which is a *linear* count rate meter (covering two decades, linearized), the other a *log* count rate meter (four decades). This affords a check of one instrument against the other. The expanded scale of the linear count rate meter affords a more precise reading of the count rate than that obtained with a suppressed scale.

Log-N Channel

The log-N, or intermediate, channel receives a current input from the CIC via a log-N Amplifier. The input stage of this amplifier is a 9004 diode. Voltage appearing across this diode is proportional to the *logarithm* of the current: thus voltage is proportional to the log of the neutron flux. This signal is amplified by a stable direct-coupled feedback amplifier and provides a 10-mv output to the log-N recorder (a Speedomax). A differentiating network differentiates log-N with respect to time and provides a −0.9 to 0 to +9.1 mv signal to the Period Recorder (another Speedo-

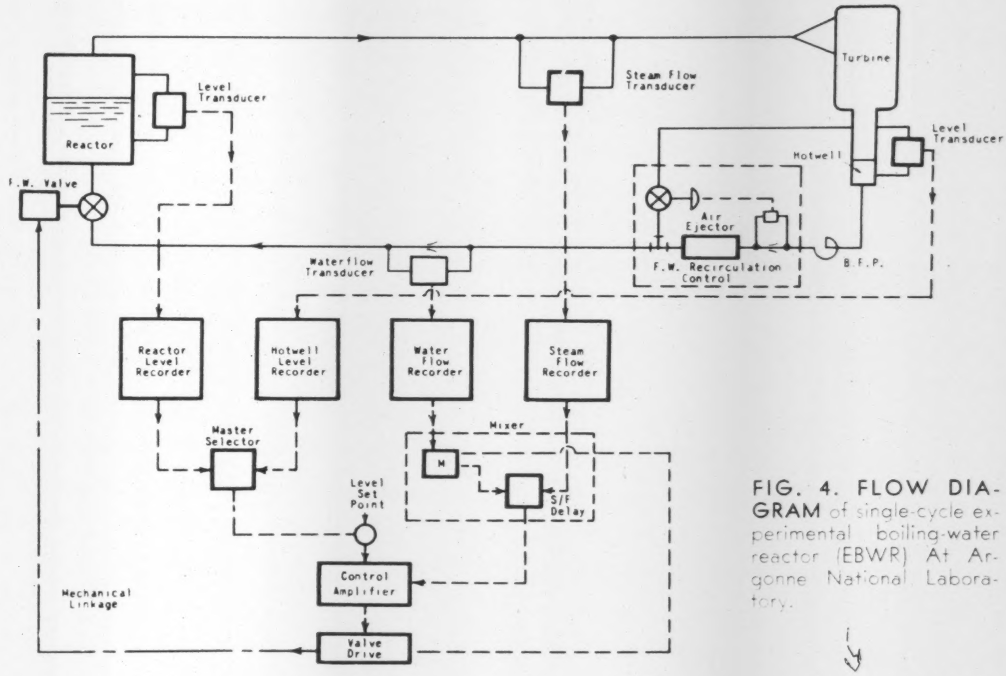


FIG. 4. FLOW DIAGRAM of single-cycle experimental boiling-water reactor (EBWR) At Argonne National Laboratory.

max). The recorder has a chart and scale calibrated from −30 to infinity to +3 secs.

A separate signal of log N is sent to a fast-response period amplifier (head-end section of the safety amplifier) for a preset *period scram* initiation. The period safety channel is in the dotted block at left in Fig. 2. Signals from the period amplifier are sent to the input of the sigma amplifier section to be coupled with the sigma bus that controls the current to the *magnet amplifier*. These magnet amplifiers have an output of approximately 50 ma to energize rod-holding magnets or latches; they are designed to break the inductive magnet current with a high speed of response without danger of arcing.

Level Safety Channels

The neutron-flux *level safety channels* are fed from uncompensated ionization chambers whose current outputs are accepted by the level safety preamp sections of the safety amplifiers. As can be seen in Fig. 2, the remaining sections of the safety channels are similar to the period safety channel. For a small research reactor, duplication of level safety channels is desirable from a safety standpoint. Both the period and level safety amplifiers are joined together with a *sigma bus* system in an "auctioneering" fashion so that a signal calling for a fast scram from any one channel will actuate all magnet amplifiers, dropping all rods. Naturally, the system is designed fail-safe so that component failure will cause a scram.

Linear Servo Channel

The Linear Servo Channel for a small research reactor generally employs a discontinuous-type servo system, as described by Davis, Underkoffler and Brey[5]. This PAT (position-adjusting type) servo is fed by a CIC through a 9836 chopper-stabilized d-c micro-microammeter and a linear recorder. The purpose of this channel is to automatically hold the flux level constant at any designated power level in the intermediate and hi-power range, and to allow changes in flux level to proceed smoothly and without overshoot. The effect of a given control-rod movement is proportional to reactor flux level—that is, at lower power levels a given δK will produce a slow change in reactor output or low gain as mentioned previously, whereas at higher power levels the same δK introduction will produce a correspondingly faster change in power output (higher gain).

This immediately suggests the desirability of automatically changing the gain of the servo loop as a function of power level to obtain control response. Fortunately, this is already accomplished by the necessary step adjustments of the range in the 9836 micro-microammeter as the ion-chamber output increases. However, if a continuous preamplifier is used, such as the level safety preamplifier, a logarithmic pot feedback into the system (or a voltage divider in the recorder) is necessary to widen the proportional band (reduce loop gain) as the flux level increases.

POWER REACTOR SYSTEMS

Perhaps the simplest type of power reactor in operation at present is the single-cycle boiling-water-type shown in Fig. 4. Steam is generated in the reactor pressure vessel by fission heat in the core. The steam passes through a steam separator drum to a turbine-generator and to the condenser, where it is pumped back to the reactor vessel to complete the cycle.

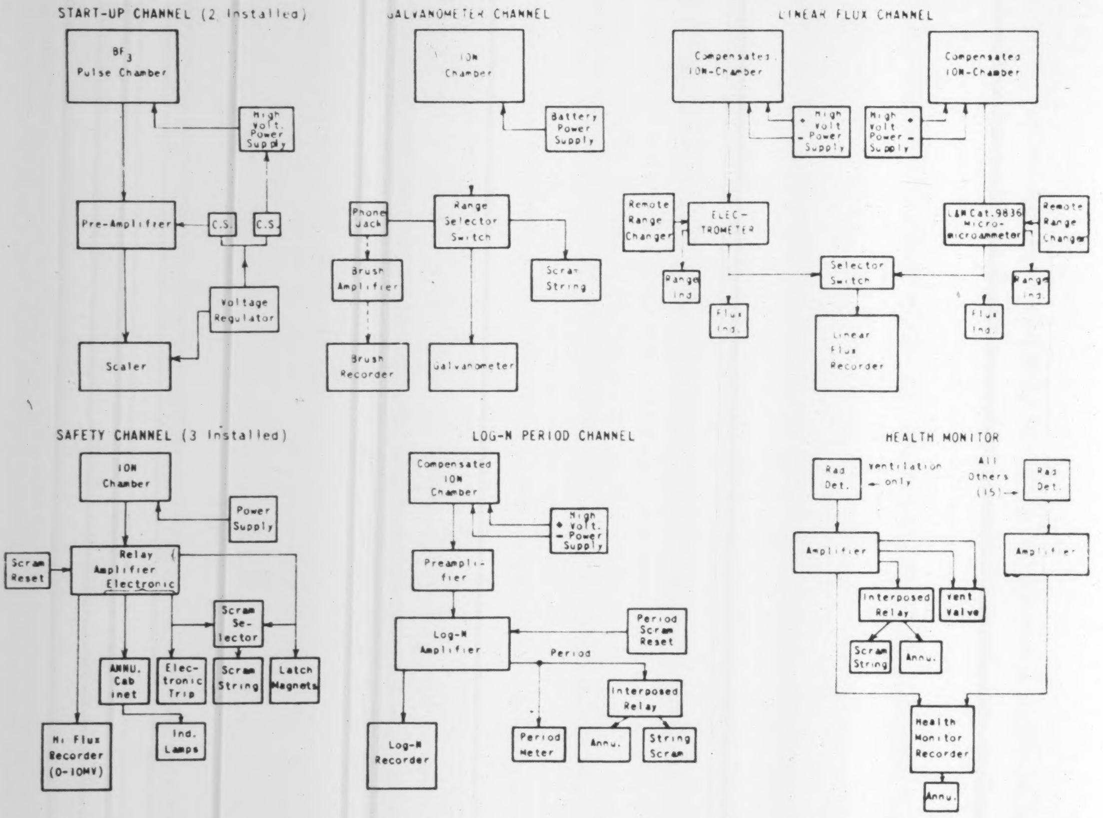

START-UP CHANNEL (2 Installed)
BF_3 Pulse Chamber
High Volt. Power Supply
Pre-Amplifier
C.S.
C.S.
Voltage Regulator
Scaler
GALVANOMETER CHANNEL
ION Chamber
Battery Power Supply
Phone Jack
Range Selector Switch
Brush Amplifier
Scram String
Brush Recorder
Galvanometer
LINEAR FLUX CHANNEL
Compensated ION-Chamber
+ High Volt - Power Supply
High Volt Power Supply + -
Compensated ION-Chamber
Remote Range Changer
ELEC-TROMETER
L&N Cat.9836 Micro-microammeter
Remote Range Changer
Range Ind
Selector Switch
Range Ind.
Flux Ind.
Linear Flux Recorder
Flux Ind.
SAFETY CHANNEL (3 Installed)
ION Chamber
Power Supply
Scram Reset
Relay Amplifier Electronic
Scram Selector
ANNU. Cabinet
Electronic Trip
Scram String
Latch Magnets
Hi Flux Recorder (0-10MV)
Ind. Lamps
LOG-N PERIOD CHANNEL
Compensated ION Chamber
High + Volt. - Power Supply
Preamplifier
Log-N Amplifier
Period Scram Reset
Period
Interposed Relay
Log-N Recorder
Period Meter
Annu.
String Scram
HEALTH MONITOR
Rad Det.
ventilation only
All Others (15)
Rad Det.
Amplifier
Amplifier
Interposed Relay
vent Valve
Scram String
Annu.
Health Monitor Recorder
Annu.

FIG. 5. NUCLEAR INSTRUMENTATION of a boiling-water reactor has nine channels—two startup channels, two linear flux channels (one electrometer and one micro-microammeter), a galvanometer channel, a log-N period channel, and three safety channels. Health channel also is shown.

A boiling-water reactor behaves, from a control standpoint, like a pressurized water reactor if the water moderator and coolant is below the saturation temperature for the existing pressure. In this condition, addition of positive reactivity results in a power rise as the reactor becomes supercritical. The "period" of this rise depends on the amount of positive reactivity introduced. If the reactor continues to rise in power, saturation temperature will be obtained when core power level reaches several kw and local boiling will begin in the fuel element matrix. As soon as boiling starts, steam bubble voids are produced, which increases the over-all neutron leakage from the core, thus reducing the positive reactivity. If no action is taken to compensate for this loss of positive reactivity (such as further withdrawal of rods) the reactor will stabilize itself at a power level where the negative reactivity in the voids equals the positive reactivity which existed in the subcooled condition. Thus, a boiling-water reactor has an inherent self-regulation.

In order to increase the power (steaming rate), it is necessary to move the control rods so as to introduce positive reactivity to over-ride the negative reactivity effect of the steam void coefficient. Thus, a fixed steaming rate will result, depending on fission product poison build-up and fuel depletion, for every position of the control rod.

BWR Nuclear Instrumentation

The nuclear instrumentation for a boiling-water reactor is generally divided into nine separate channels as described by Lipinski and Ramp.[6] Basically these channels can be grouped into *startup, intermediate* and *hi-power ranges* (Fig. 5). Fig. 6 shows the flux ranges of the nine nuclear instrumentation channels. The figures are based on an ion chamber sensitivity of 10^{-14} amp neutron cm^2 sec and a neutron flux density in the chamber tubes of 2×10^9 neutrons cm^2 sec at 20 megawatts core power.

As shown in Fig. 5, both of the startup channels use BF_3 chambers as primary elements.

Both the electrometer and 9836 micro-microammeter channels (shown at right) bracket the startup and intermediate power ranges. The electrometer is fed from a compensated ionization chamber. As lead length affects the time constant of this instrument, the amplifier is located as close to the chamber as possible. Range changing is done remotely from the control with a rotary solenoid switching unit (Ledex). Amplifier output and range selector switch position are displayed at the reactor console. Another output goes to the Linear Recorder (Speedomax) at the reactor console.

The 9836 micro-microammeter channel is similar. The Linear Flux Recorder also can be used to record the output of this amplifier.

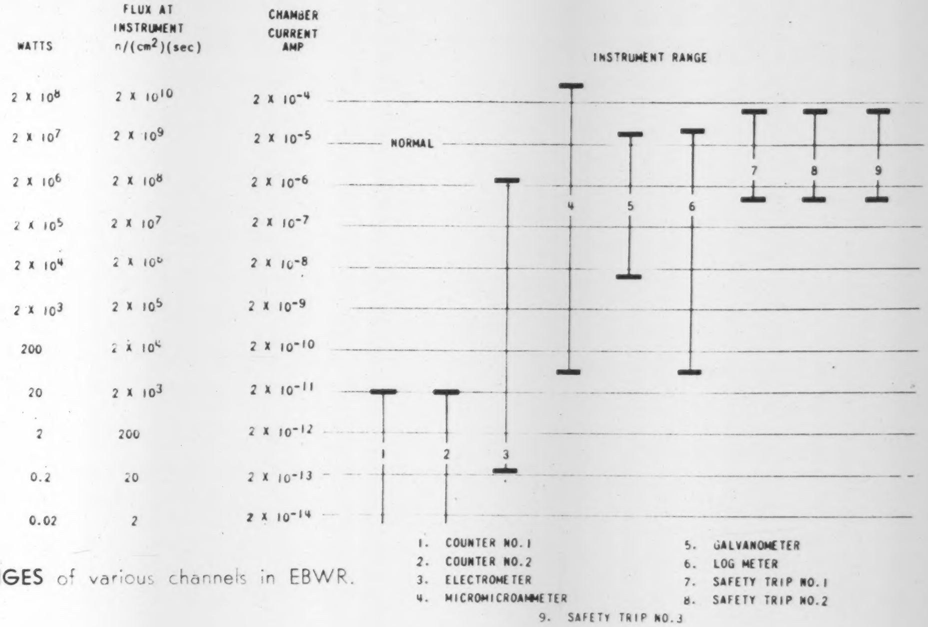


FIG. 6. RANGES of various channels in EBWR.

Both the galvanometer and log-N period channels (center) cover the intermediate power range and are fed from CIC's. The galvanometer has a sensitivity of 3×10^{-10} amp/mm. The addition of a shunt extends the range 333 times. Batteries supply both the ion chamber high-voltage supply and the galvanometer lamp. The galvanometer channel would be the only indication of flux conditions in event of complete electric power failure. This is of interest even though the reactor is scrammed by power failure, primarily to watch delayed neutron flux decay.

Log-N and Period Channel

The log-N and period channel is the same as described previously for research reactors. The log-N signal is displayed on a log-N recorder at the console, with period indicated on a meter. A period trip circuit is also provided and set for approximately 10 sec. A keyswitch is provided to bypass the period trip circuit when the reactor is boiling.

Safety Channel

Three identical level-safety channels generally are employed on a reactor of this type. These channels act to prevent any abnormally high excursions of neutron flux. The ion-chamber current actuates a sensitive relay and safety amplifier. The trip level on the safety amplifier (generally 110% of full power) is set lower than the trip set point on the sensitive relay (125% of full power). The safety amplifiers are operated together in "coincidence" circuitry—two of the three amplifiers must be tripped before a fast scram is initiated. If a single safety amplifier fails, a warning signal is displayed in the control room. This type of level-safety amplifier arrangement helps avoid spurious scrams due to electronic component failures, chamber or power-supply failures, etc. On the other hand, the sensitive relays are arranged to operate on the "auctioneering" principle. Thus, actuating any relay will cut the power to the magnetic latches and scram the reactor.

In addition to the flux monitoring and safety channels described, many startup and shutdown interlocks are employed.

Feedwater Control System

The feedwater system for a boiling-water reactor (Fig. 4) generally permits control of level from either the hotwell or the reactor vessel. There also should be the ability to switch from simple proportional control (level control adjusting the main feedwater) to two-element control (using either steam flow or feedwater flow as the second element), to three-element control (using level, feedwater flow and steam flow), or to a four-element system (using level, feedwater flow and steam and velocity feedback from the feedwater valve).

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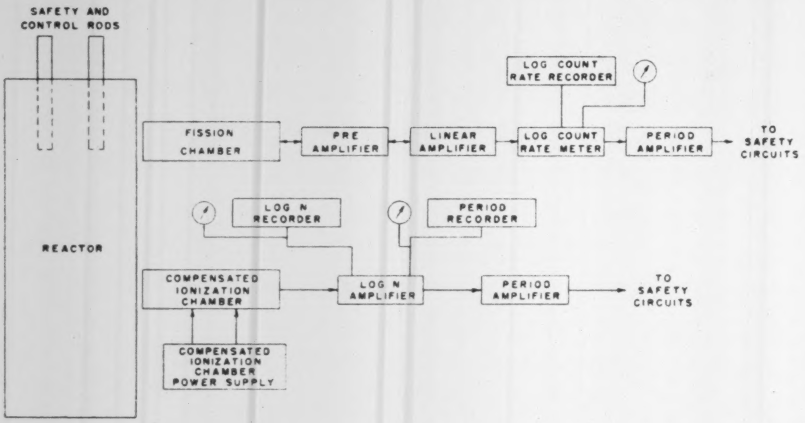

FIG. 1. REACTOR start up instrumentation.

Power Reactor Control

The power reactor usually is controlled from two variables—the load and the neutron level.

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THERMAL reactors are controlled by manipulation of control, safety, and shim rods. These rods are fabricated of materials that have a high absorption cross-section for neutrons. Cadmium and boron are most commonly used. Usually, these are contained in stainless steel to provide structural rigidity and corrosion resistance. The safety rods provide several percent of negative reactivity for all possible conditions of the reactor. When inserted into the active core of the machine, they quickly stop the chain reaction or, in reactor terminology, "scram" the reactor. The shim rods are used to provide reactivity control in amounts depending on the operating conditions of the reactor. As the fuel becomes depleted through burn-up, or as poisons build up in the reactor fuel, it is necessary to make slight adjustments of the shim rods to maintain the desired reactor power level. The function of the control rod is to provide fine reactivity control for the reactor.

In order to start the reactor operating, the safety rods must be withdrawn from the reactor. However, they must be in a position to be quickly inserted into the core of the reactor if unfavorable operating conditions arise. These rods are supported by electromagnets, and the current to these magnets is supplied from instruments. Circuits from these instruments are designed so that when dangerous conditions exist, the magnet current to these magnets will decrease to a value below that required to support the rods. Hence the rods fall into the fuel assembly, and the reactor scrams.

Basically, there are three primary considerations that must be taken into account in controlling the nuclear reactions of all reactors.

1. The neutron flux of the reactor must not be allowed to exceed the maximum levels for extended periods of time.

2. The positive period of the reactor must not be permitted to become too short. Reactor period (the time required for the neutron flux to change by a factor of e, or 2.718) is positive when the neutron flux is increasing, negative when it is decreasing. The heat generated by the reactor is proportional to the number of fissions occurring in the fuel. Therefore, if excessively short periods are allowed, the fuel assemblies could be damaged before the heat is transferred to the surface for removal by the reactor coolant.

3. The neutron flux must be maintained at a constant value for extended periods of time, but must be capable of following load changes.

Reactor Startup

Fig. 1 is a block diagram of the instruments used in reactor startup. The fission chamber is used for detecting neutron flux at very low levels. The linear amplifier, by means of a pulse height selector, transmits only those pulses resulting from fission. The output of the pulse height selector is fed to a log count rate meter, which averages a series of electrical pulses. The log count rate meter supplies an output signal proportional to the logarithm of the number of input pulses per second. This output is fed to a meter for

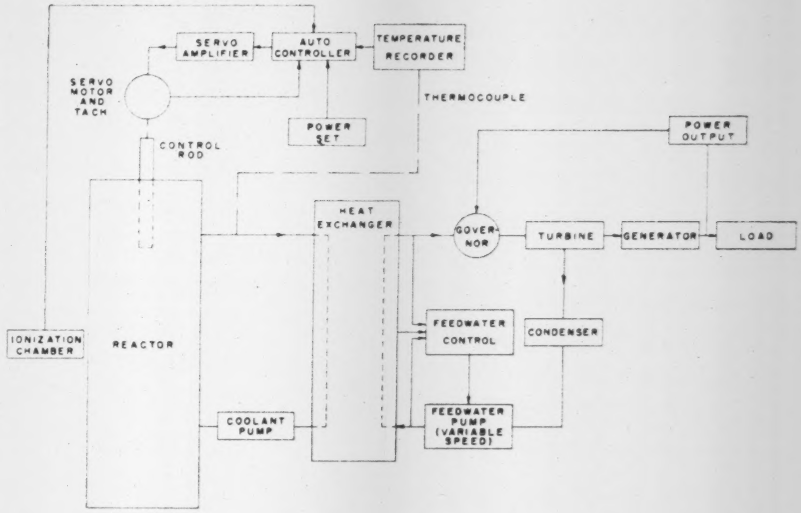


FIG. 2. CONTROL SYSTEM for a reactor based on control of outlet coolant temperature and neutron activity.

indication and a recorder for graphic presentation. The meter and the recorder scales are logarithmic, and may include a range from one to six decades.

Protection against excessive reactor period is necessary for the low levels at which the counting rate channel is effective. Therefore, a period amplifier follows the log count rate meter. It accepts an input voltage whose time derivative (rate of change) is obtained; therefore, the output signal is a voltage proportional to the rate of change of the neutron flux of the reactor. This voltage is supplied to relay circuits which operate a relay in series with the magnet current power supply. Thus, if the period of the reactor exceeds a predetermined value, the magnet current is de-energized, and the reactor scrams.

By the time the neutron flux of the reactor is of sufficient magnitude to approach the upper limits of the counting rate channel, other instruments are capable of supplying information to the operator and the safety circuits. One group of instruments used for this purpose is called a *log power and period channel*. This channel consists of a compensated ionization chamber, its power supply, a log-N amplifier, and a period amplifier.

In the amplifier the input signal flows from plate to cathode of a 9004 diode. When such a current is small the voltage across the diode is proportional to the logarithm of the current. Hence the d-c signal at the input of the amplifier is proportional to the logarithm of the neutron flux. This signal is amplified and indicated on a meter and recorded on a recorder. The meter scale and the recorder have logarithmic calibrations.

A differentiation network is provided in the log-N amplifier to differentiate the signal to indicate the reactor period (rate of change of neutron flux). This signal is also supplied to a meter for indication and a recorder for graphic presentation.

Following the log-N amplifier is a *period amplifier*. This amplifier is a coupling device between the log-N amplifier and the safety circuits. As previously described, the time derivative of the logarithmic signal is obtained. However, in this case the output is supplied to the magnet current circuit to initiate a reactor scram if excessively short periods are realized.

Protection Against Excessive Power Levels

It is necessary to incorporate control equipment that will quickly shut the reactor down if unsafe levels are reached. The group of instruments for this purpose consists of an uncompensated ionization chamber and a safety amplifier (not shown).

Power Operation

Any one of several methods of control may be selected for a power reactor. The method chosen will be dictated by the basic requirements of the plant. An ideal situation is for the reactor to be an inherently self-regulating machine, with no electronic and mechanical controls required to regulate its power output. A reactor having a *negative temperature coefficient* and operating on a program of maintaining the average coolant temperature constant will substantially contribute to this ideal situation. A reactor having a negative temperature coefficient is one whose reactivity decreases as its average temperature increases.

It may be desirable to maintain the reactor outlet temperature constant. Such control instrumentation is shown in Fig. 2. It consists of a recorder measuring reactor outlet temperature, a controller, and a servo amplifier. The controller receives inputs from a transmitting slidewire in the temperature recorder, a power level set control, a tachometer feedback, and a neutron detecting ionization chamber. The system is designed to regulate the reactor outlet temperature to a value determined by the setting of the power level control. Provisions are made for the neutron signal to over-ride the power level signal when the neutron flux approaches excessive levels. The tachometer feedback is used for servo stabilization. The servo amplifier receives the error signal produced by the controller and drives the servo motor mechanically linked to the control rod.

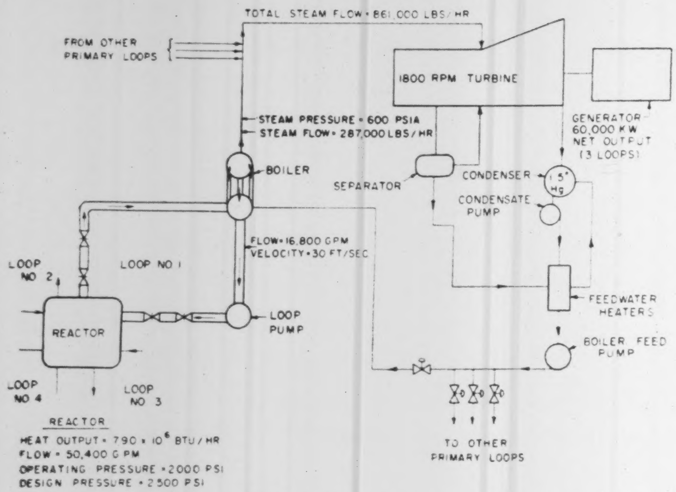

TOTAL STEAM FLOW • 861,000 LBS/HR
FROM OTHER PRIMARY LOOPS
1800 RPM TURBINE
STEAM PRESSURE • 600 PSIA
STEAM FLOW • 287,000 LBS/HR
GENERATOR 60,000 KW NET OUTPUT (3 LOOPS)
BOILER
SEPARATOR
CONDENSER
1.5" Hg
CONDENSATE PUMP
FLOW • 16,800 GPM
VELOCITY • 30 FT/SEC
LOOP NO 2
LOOP NO 1
FEEDWATER HEATERS
REACTOR
LOOP PUMP
BOILER FEED PUMP
LOOP NO 4
LOOP NO 3
REACTOR
HEAT OUTPUT • 790 x 10^6 BTU/HR
FLOW • 50,400 GPM
OPERATING PRESSURE • 2000 PSI
DESIGN PRESSURE • 2500 PSI
TO OTHER PRIMARY LOOPS

FIG. 1. ELEMENTS of the Shippingport reactor.

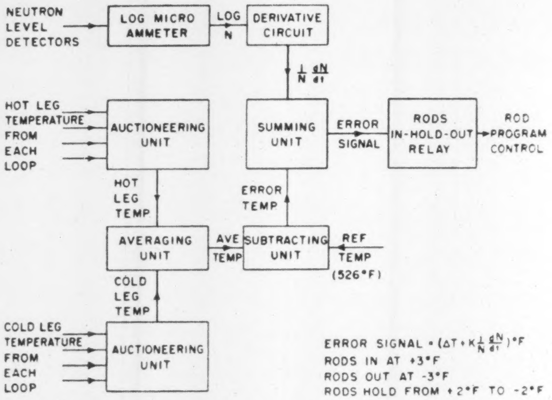

NEUTRON LEVEL DETECTORS
LOG MICRO AMMETER
LOG N
DERIVATIVE CIRCUIT
1/N dN/dt
HOT LEG TEMPERATURE FROM EACH LOOP
AUCTIONEERING UNIT
SUMMING UNIT
ERROR SIGNAL
RODS IN-HOLD-OUT RELAY
ROD PROGRAM CONTROL
HOT LEG TEMP
ERROR TEMP
AVERAGING UNIT
AVE TEMP
SUBTRACTING UNIT
REF TEMP (526°F)
COLD LEG TEMP
COLD LEG TEMPERATURE FROM EACH LOOP
AUCTIONEERING UNIT
ERROR SIGNAL = (ΔT + K 1/N dN/dt)°F
RODS IN AT +3°F
RODS OUT AT -3°F
RODS HOLD FROM +2°F TO -2°F

FIG. 2. METHOD BY WHICH the control signals of the Shippingport reactor are combined for rod control.

The Shippingport Reactor

is controlled by (1) temperature of water in coolant loops and (2) reactor power signal (neutron level).

SHIPPINGPORT reactor of Duquesne Light Company is the nation's first reactor to supply electric power to a city area. Fig. 1 shows the elements of the system, which is a joint project of Westinghouse Electric Corporation, the AEC, and Duquesne Light. A large share of the instrumentation was performed under AEC bids by Norwood Controls; Bailey Meter Company built the instrument panels; the instrumentation includes equipments supplied by Foxboro, Minneapolis-Honeywell, Leeds & Northrup, Assembly Products, and many other instrument companies.

The reactor supplies four coolant loops in order to keep piping sizes at reasonable values. Heat is carried from the reactor by highly purified water flowing through three primary loops (the fourth is spare) to steam generators (heat exchangers). Steam flow from the steam generators flows to the turbine via a common header. Two of the loops use Foster-Wheeler type exchangers; two use Babcock & Wilcox exchangers for comparison.

Control is based on the average temperature of the coolant (rather than steam pressure) in order to keep the control system simple and to take advantage of the reactor's inherent negative temperature coefficient of reactivity. The only disadvantage of this is that the steam pressure varies from no-load (834 psi) to full load (600 psi), which resulted in some increase in steam plant costs.

The basic variable is outlet water temperature (542 F), measured by two resistance thermometers in each primary loop, one in the hot leg and one in the cold leg.

The temperature signals are combined with a reactor power signal (neutron level) as shown in Fig. 2. Use of the derivative signal of neutron flux gives rate of change, or anticipatory, control.

The water pressure in the pressurized system also is controlled at 2000 psi within 10 psi.

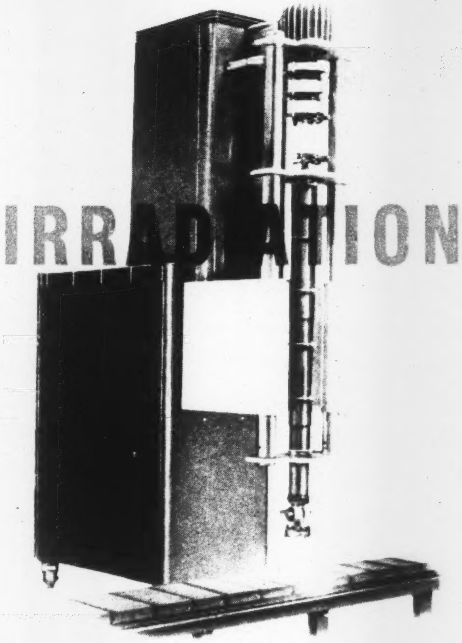
Level in the pressurizer also is controlled via d-p cells. This signal is useful because it gives immediate indication of plant operation.

A rapid measure of reactor operation also is obtained via measurement of leakage neutron flux with a BF_3 and compensated ion chambers.

Sixty annunciators are used to monitor all operations. Simulation of the control system has shown that all transients can be handled by the system. The instrumentation, which was expected to be accurate to about 2%, turned out to have an accuracy of better than 1%.

MORRIS R. JEPPSON
Applied Radiation Corporation

IRRADIATION Sources for Industry



This appraisal of various radiation sources compares advantages and costs of radioactive waste and other reactor sources versus accelerators of various types.

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TABLE 1—RADIATION SOURCES

1. REACTOR-PRODUCED RADIATION
   - A. Direct use of gamma rays produced during operation of reactor
   - B. Radioactive materials produced by reactors
     - a. Waste fission products
     - b. Radioactive fission gases
     - c. Cobalt-60 produced by neutron activation in a reactor
2. ACCELERATORS FOR PRODUCTION OF RADIATION
   - A. Direct high-voltage machines
     - a. Conventional x-ray machine
     - b. Resonant transformer
     - c. Van de Graaff generator
     - d. Capacitron
     - e. Genetron
   - B. Resonance-type accelerators
     - a. Linear accelerator
     - b. Microtron or electron cyclotron
     - c. Synchro-cyclotron
     - d. Synchrotron
   - C. Acceleration by magnetic induction
     - a. Betatron

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TABLE 2—APPROXIMATE FISSION ENERGY BALANCE*

Kinetic energy of fission fragments	168 Mev
Radioactive decay energy	21 "
Energy of neutrons	6 "
Instantaneous gamma-ray energy	6 "
	201 Mev

*From "Source book on Atomic Energy," by Samuel Glasstone, D. Van Nostrand.

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RADIATION USES by industry—including sterilization of food and drugs, production and treatment of chemicals and plastics, and change in properties of electronic components—has been delayed by lack of suitable radiation sources. The two general approaches to producing low-cost high-intensity radiation are classified in Table 1.

Reactor-Produced Radiation

The total amount of energy released by the fission reaction in uranium is 201 Mev (million electron volts) per atom. This energy has the forms listed in Table 2.

The instantaneous gamma-ray energy accounts for 3% of the total reactor output power and appears to be a ready source of radiation. However, these gammas are released throughout the reactor core and only a fraction can be used. Moreover, the instantaneous gammas are mixed with neutrons which can induce radioactivity in the product being processed. Thus, this source loses its appeal.

Waste fission products from reactors have received considerable publicity. The delayed energy released from the fission reaction, including the energy of beta particles and neutrinos as well as gamma-ray energy, is about 10% of the total fission energy. A multitude of fission product isotopes, the so-called *radioactive wastes*, are produced in amounts ranging from about 10^{-5} to as much as 6% of the original number of uranium atoms.

The Atomic Energy Commission has been interested in finding practical applications for the accumulating radioactive wastes from its production reactors. This waste material, left after the recovery of plutonium and uranium, is not in desirable form for use as a radiation source. The most suitable radioisotope components of the fission product wastes are Cerium-Praseodymium 144 (300-day half life) and Cesium-Barium 137 (33-year half life). These account for 5%

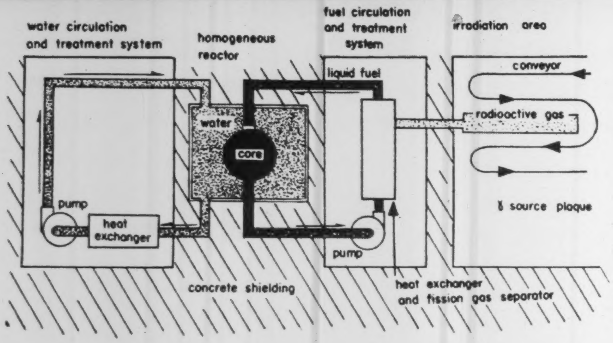
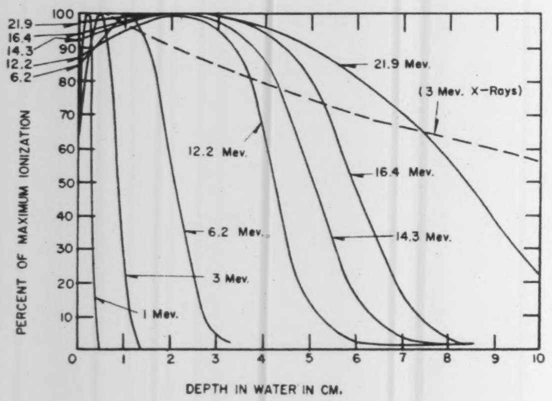


FIG. 1. PROPROSED IRRADIATION FACILITY using radioactive fission-product gases.

FIG. 2. PENETRATION of high-energy electrons in water.



and 6% respectively of the total yield of fission isotopes. However, they are mixed with the other undesirable isotopes which reduce the effectiveness of the source by self absorption of the radiation.

A megacurie source will sterilize approximately 1 ton of food per hour. To make a one-megacurie source of Cesium 137 (33-year half life) requires the burnup of 800 pounds of uranium. If this burnup took place in 1 year, the continuous rate of thermal energy produced during the year would be 1000 megawatts. In other words, a 1000-megawatt reactor, a large installation, would yield only a single 1-million-curie Cesium source each year.

It appears that gross fission products and separated fission isotopes cannot be considered as practical industrial sources *at this time*.

Radioactive Fission Gases

Some 1% of the fission energy in a reactor appears in the form of radioactive gases Xenon and Krypton.[1] Loftness[2] and others have indicated that these gases can be removed from a solution-type reactor and pumped through an irradiator.

Fig. 1 shows how an installation of this type might be designed. Source strengths obtainable would be approximately 3 kilowatts of useful gamma energy per megawatt of reactor power. Loftness estimates that a 3-megawatt solution-type reactor facility would cost approximately $1,800,000.

Cobalt-60 by Neutron Activation

Perhaps the most realistic uses of reactor power to obtain radiation sources for industry is by neutron activation of Cobalt-60 in large enriched-fuel reactors. This abandons the idea that industry use the waste products of weapons production and nuclear power activities. In fact, production of Cobalt-60 will increase the problem of radioactivity waste disposal.

The advantages of Cobalt-60 over other radioactive sources are considerable. Colbalt metal can be prefabricated into certain desired source shapes before being activated in a reactor, and there are no chemical separation problems; there is the hazard of handling hundreds of pounds of intensely radioactive material.

The economic factors in Cobalt-60 production are as follows: An estimated cost for neutron activation of Cobalt in a production-type reactor is approximately $.25 per curie; a megacurie source would cost about $400,000, installed.

The relatively low-power research reactors at Oak Ridge and Brookhaven have limited production capacities. For example, one of the largest single Cobalt-60 sources yet produced (4000 curies) was produced in the Brookhaven reactor and required a period of more than two years. To produce the megacurie sources needed by industry will require large reactors.

The AEC could, in the interest of promoting peaceful uses of atomic energy, make a portion of its plutonium production facilities available for the production of Cobalt-60. Space in the Savannah River reactors already is to be made available for production of Cobalt-60 for teletherapy. However, these are comparatively small sources. A 100-megawatt enriched-fuel reactor capable of producing a dozen one-megacurie Cobalt sources a year would require an investment of $8,000,000.

Radiation by Accelerators

Radiation also can be produced by machines and electronic devices which accelerate electrons to energies of millions of volts. High-energy electrons (in the range of 2 to 12 Mev) produced by machines can be used either directly as a source of ionizing energy or can be converted into x-rays when increased penetration is desired.

The depth of penetration of an electron beam as a function of energy is shown in Fig. 2. For comparison, the half-value penetration in water for 0.66-Mev gammas from Cesium-Barium 137 is 3″, and that for 1.33-Mev gammas from Cobalt-60 is about 4″. The number of practical uses for electron beams can be expected to increase with increased beam energy. However, there is an upper energy limit imposed by the generation of neutrons. For food processing applications this limit will probably be in the range of 8 to 12 Mev.

A typical food-processing plant could use two accelerators injecting electrons into a prepackaged product from two sides. This gives maximum use of the electron beam and uniform dosage vs depth. For example, two 10-Mev units could irradiate prepackaged meats in thicknesses up to 3″ with a uniformity in depth of ± 20%.

There are fundamental differences between accelerator-produced radiation and radiation from isotopes. Only the gamma rays from reactor products are useful.

and they are emitted in all directions. In contrast, both the electron beam and the x-ray beam from a linear-type accelerator are directional within angles of 30° or less.

Electron-beam energy can be converted to x-rays for increased penetration (Fig. 2). However, the low conversion efficiencies (Fig. 3) show it is best to make use of the electrons directly, wherever possible.

Conventional X-Ray Machines

Medical and industrial x-ray machines operate at potentials up to 260,000 volts. Conversion efficiency for making x-rays at this energy is only about 1%, and the electrons have so little range that they cannot be used effectively for industrial purposes.

Resonant-Transformer Accelerators

The General Electric Company has manufactured a number of 1- and 2-Mev resonant-transformer units for industrial radiography and other uses. Basically the resonant transformer is a pressurized-gas, insulated, tuned transformer incorporating a multi-stage accelerating tube across the high-voltage secondary winding. It is compact and simple.

It is an a-c device with the accelerating tube providing half-wave rectification. A disadvantage is the varying output voltage during the voltage half cycle, which tends to introduce low-energy electrons into the output beam. Units with energies of 4 Mev and beam power up to 20 kilowatts have been tested.

Van De Graaff Accelerators

The Van de Graaff accelerator (Fig. 4), a widely used device for nuclear physics research, has been brought to an advanced stage of development by High Voltage Engineering Corporation. It is an electrostatic machine in which an electric charge is sprayed on a moving belt that transports it to a high-potential point (3). The high-voltage terminal is insulated from the shell by an atmosphere of compressed nitrogen (4). Electrically charged particles (5) are made available for acceleration from a heated cathode (for electrons) or a gaseous discharge (for positive ions). These positive or negative particles can be injected into an accelerating tube (6) placed across the d-c potential. This is a glass and metal tube, maintained at a high vacuum, which provides the path for the charged particles to escape from the high-voltage terminal.

The good voltage regulation which can be obtained is important in the production of monoenergetic beams needed for nuclear physics research. The highest power unit is a 3-Mev 10-kw electron machine that costs over $400,000. A practical upper limit in output energy is about 3 Mev for this type of accelerator.

The Capacitron

The Capacitron uses the principle of charging capacitors in parallel and then connecting them in series across the accelerating tube to produce an output voltage equal to the number of capacitors multiplied by the voltage of the charging power supply. The Capacitron, manufactured by Electronized Chemicals Corporation, delivers the beam in short intense pulses. Again, the practical voltage limit is about 3 Mev.

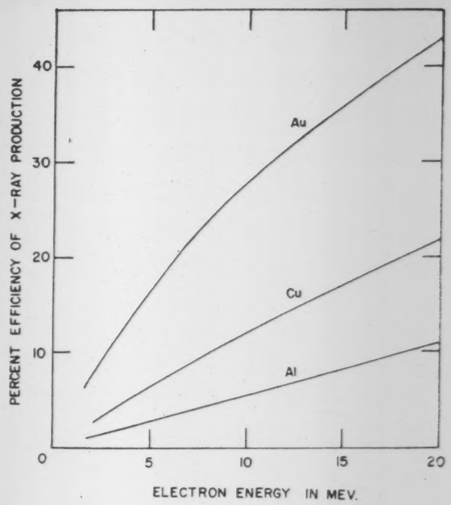


FIG. 3. EFFICIENCY of x-ray production of various targets from high-energy electrons. (Data after C. W. Miller.)

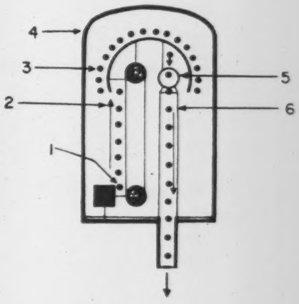


FIG. 4. VAN DE GRAAFF accelerator accelerates electrons, protons, or heavier positive ions by the potential difference between the high-voltage terminal at top (3) and lower end of accelerator.

The Genetron

The Genetron uses cascaded 250,000-volt d-c power supplies (the type used for medical x-ray machines) to give a high-voltage d-c supply. It has low ripple and can deliver as much as 50 kw at 1 to 3 Mev.

The Genetron is not being manufactured but is mentioned here because of its unusually high power capacity and because certain of its features have been incorporated into accelerators which are now in use.

All of the accelerator types discussed so far must provide insulation to sustain the full output voltage. The evacuated accelerating tube also must withstand the full voltage. This limits the output energy to about 3 Mev.

Resonance-Type Accelerators

These insulation limitations are not present in resonance-type accelerators which accelerate charged particles by successive applications of a moderate potential.

Electron Cyclotron or Microtron

The cyclotron (Fig. 5), invented by Dr. Lawrence at the University of California, is the most familiar of the resonance accelerators. A magnetic field causes charged particles to travel in circles of ever-increasing radii as they are periodically acted upon by an accelerating voltage.

The charged particles are usually heavy positive ions (ionized atoms of hydrogen or deuterium formed near the center of the chamber by a source such as a

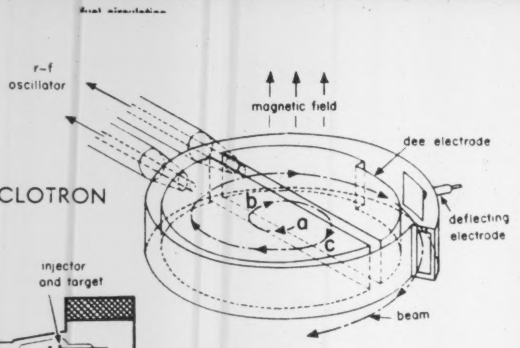

r-f oscillator
magnetic field
dee electrode
b
a
c
deflecting electrode
beam

FIG. 5. THE CYCLOTRON

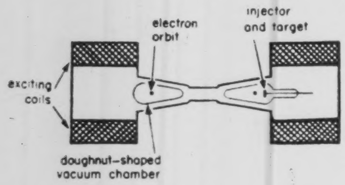

electron orbit
injector and target
exciting coils
doughnut-shaped vacuum chamber

FIG. 6. THE BETATRON

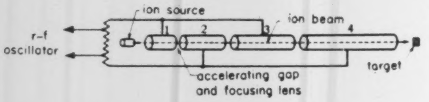

ion source
ion beam
1
2
3
4
r-f oscillator
accelerating gap and focusing lens
target

FIG. 7. IN THE LINEAR ACCELERATOR, charged particles are accelerated by a traveling r-f field.

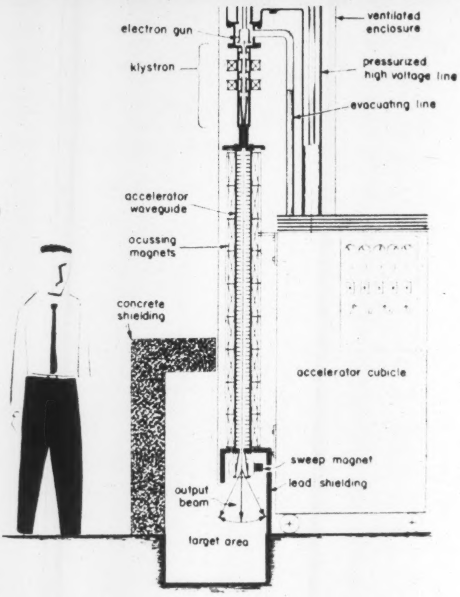

electron gun
klystron
ventilated enclosure
pressurized high voltage line
evacuating line
accelerator waveguide
focussing magnets
concrete shielding
accelerator cubicle
sweep magnet
lead shielding
output beam
target area

FIG. 8. TYPICAL INSTALLATION of Arco Mark I electron linear accelerator set up for laboratory irradiations.

filament and grid system whose electrons ionize some gas in the chamber). If a proton (hydrogen ion) starts at A it is accelerated each time it passes the gap between the two D-shaped electrodes. Once past the gap it is bent into a circular path by the magnetic field and returned back to the gap. The polarities of the D-shaped electrodes are reversed each time the oscillator tubes change polarity, and the protons reach the gap at the instant of maximum acceleration on each cycle.

Using the cyclotron principle to accelerate *electrons* is difficult because the light, negatively-charged electrons approach the speed of light rapidly at comparatively low energies. Near the speed of light the electrons change mass (as predicted by relativity theory considerations), which in turn causes them to get out of step with the applied r-f voltage. The cyclotron no longer functions properly when this occurs.

Synchro-Cyclotron

This difficulty can be overcome by gradually reducing the frequency of the r-f voltage applied to the electrodes as the particle increases in speed. However, no new particles can be started and only one batch of electrons or particles can be brought through the acceleration process. This reduces the current output. Machines using this technique are called synchro-cyclotrons.

As the electron current output of cyclotrons and synchro-cyclotrons is low, these techniques for accelerating electrons are not useful for industrial applications.

The Synchrotron

Instead of varying the frequency of the r-f field as the mass of the particle increases, it is possible also to vary the magnetic field H as the mass increases. This is done in *synchrotrons.* Machines of this type have been built for particle energies of 300 Mev, but again they are not suitable for industrial applications because of limited electron current.

The Betatron

In the betatron (Fig. 6), the field supplied by the a-c magnet not only accelerates the electrons but it also increases as the speed of the electrons increases, causing the electrons to stay in one orbit. The electrons make a large number of revolutions, picking up energy on each. The electrons can be made to strike a target by unbalancing the magnetic field at the proper instant. The current output of the conventional betatron is very low (Table 3).

Fixed-Field Alternating-Gradient Betatron

The Midwestern Universities Research Association is planning the construction of the highest energy proton accelerator in the world. Under the leadership of Professor D. W. Kerst of the University of Illinois, the Midwestern group has developed the principle which is called fixed-field alternating-gradient, or simply FFAG.

The University of Michigan has now successfully operated an electron model of the FFAG betatron. It has been predicted that continued development of this new accelerator technique could ultimately result in electron beam powers of 50 kilowatts at 50 Mev.

Electron Linear Accelerator

Professor Hansen and his associates at Stanford University were responsible for the successful development of the traveling-wave electron linear accelerator in this country. This accelerator represents a successful combination of physics and high-power microwave engineering.

The basic requirements for the traveling-wave accelerator are (1) a multi-megawatt source of radar-frequency power, (2) a specially-constructed waveguide, and (3) a source of energetic electrons (Fig. 7).

TABLE 3—COMPARISON OF PARTICLE ACCELERATORS

Name	Highest Energy Obtained* (Mev)	Characteristics
Van de Graaff	8	Accelerates electrons, protons, deuterons, or heavier positive ions. Has steady voltage, continuous high or low currents.
Cyclotron	20	Accelerates protons, deuterons, or helium ions. Has high voltage, high average current.
Synchro-cyclotron	370	Accelerates protons, deuterons, helium ions. Has high voltage, low current.
Synchrotron	1000	Accelerates pulses of electrons. Very low current.
Betatron	100	Accelerates pulses of electrons. Very low current.
Electron Linear Accelerator	300	Accelerates pulses of electrons, protons, deuterons, or heavier positive ions. Moderate current.

*Figures are only orders of magnitude. For example, it has been proposed to develop synchrotrons of up to 6000 Mev, electron linear accelerators of up to 40,000 Mev.

A fundamental advance in concept has been made by R. F. Post in the design (developed recently by Applied Radiation Corporation) that uses the r-f power source (a high-power klystron) as the electron injector for the waveguide. Fig. 8 traces the electron beam through the accelerator, showing how electric power is converted to electron beam power.

The cathode of the electron gun is pulsed by voltages in the range of 150,000-250,000 volts, with pulse lengths of 10 to 50 microseconds. In the unit shown in Fig. 8, current pulses of 50 amperes peak pass through a hole in the anode face and through the klystron, which is a succession of resonant cavities separated by drift tubes. A small amount of r-f energy in the first cavity is amplified to a high-power in the output cavity. A magnetic field prevents the beam from blowing up before it reaches the collector. Energy from the pulsed electron beam, now converted into r-f energy, is then transmitted through a hole in the collector-coupler into the accelerator waveguide where it is propagated as a *traveling wave* towards the output end.

This new concept makes possible the very-high-power beam needed for industrial processing. Table 4 shows specifications for two models of the Post design.

Comparisons

Table 5 compares the most promising radioactive source (Cobalt-60) with the most promising machine source (the electron linear accelerator).

Table 6 compares the economies of 3 sources—fission gas, Cobalt-60, and the electron linear accelerator.

Neither linear accelerators nor large radioactive sources have been used as yet in a commercial operation. Undoubtedly there will be applications for which one source or the other will be superior, as determined by trial and experience.

TABLE 4—IMPROVED LINEAR ACCELERATORS

Specification	Mark I	Mark 20 (Proposed)
Electron beam energy	6 Mev	Up to 25 Mev
Electron beam power	4 kw	60 kw
Peak beam current	200 ma	20 ma
Average beam current	0.7 ma	3 ma at 20 Mev
Pulse length	10 microseconds	40 microseconds
Repetition rate	1, 30, 60, 120, 360 per second	

TABLE 5—COMPARISON OF COBALT-60 AND ELECTRON-LINEAR ACCELERATORS

Advantages	
Cobalt-60	Accelerators
1. Simple mechanically and electrically	1. Produces both electrons and x-rays with high directivity
2. Reactors already exist which could produce sources	2. Can be turned off
3. Can be made in any sizes	3. No fissionable material
4. Greater penetration than electrons from accelerators	4. Accelerators available now
	5. No danger of radioactive contamination
	6. X-rays have greater penetration than gammas from Cobalt-60
Disadvantages	
1. Not now available in sizes needed	1. Intricate electronic device
2. High cost for a facility to produce large sources	2. Periodic replacement of some parts
3. Can't be turned off for installation or maintenance	3. Cannot be made arbitrarily small to compete with small cobalt sources

Table 6—Capital Costs per Kilowatt of Radiation Capacity.

Type of Source	Estimated Initial Cost of Source	Source Cost per kw of Radiation Output
Fission gas facility (0.16 Megawatt reactor)[2]	$ 350,000	$ 700,000
Fission gas facility (2.9 Megawatt reactor)	$1,800,000	$ 120,000
Cobalt-60 (made in an enriched fuel reactor)[4] (1 megacurie size)	$ 400,000	$ 33,000
Accelerator (4-kw 6-Mev using electrons)[3]	$ 125,000	$ 31,000
Accelerator (4-kw 6-Mev using x-rays)	$ 125,000	$ 170,000
Accelerator (60-kw 10-Mev using electrons)	$ 300,000	$ 5,000
Accelerator (60-kw 10-Mev using x-rays)	$ 300,000	$ 18,000
Accelerator (400-kw 12-Mev using x-rays)	$ 450,000	$ 3,700

References

1. H. M. Busey, "Composition and Decontamination of Residual Water Boiler Off-Gas," LA-1521, March, 1953.

2. R. L. Loftness, "Radiation Processing with Nuclear Reactors," Proceedings 1955 Conference on Nuclear Engineering, California Book Co., Berkeley, Calif.

3. R. F. Post and M. R. Jeppson, "High Power Electron Linear Accelerators for Industry and Research," ibid.

4. A. T. Biehl, "A Comparison of Electron Accelerators and Nuclear Reactors and Sources of Gamma Radiation," unpublished paper, 1955.

This analog study of a typical wet process was performed without elaborate frequency response testing or plant experimentation by using an approximate analog consisting of actual instruments plus simulated process units.

LLOYD G. LEWIS
Standard Oil Company (Indiana)

SIMULATION OF A SOLVENT RECOVERY PROCESS

ANALOG METHODS used to simulate a process depend on (1) the capabilities of the computer and (2) the nature of the process unit. They also depend on (1) the nature of the available plant information and (2) the availability of process equipment for experimentation.

Little is known about the transfer functions for particular pieces of plant hardware; one is fortunate to get even complete detailed engineering drawings of all items. Under these circumstances the transfer-function approach commonly used by servo designers is not feasible for most process applications.

Usually only a few frequency-response tests can be made on individual pieces of plant equipment because the items are not available before the unit is built. After it is built the manufacturing department is reluctant to interfere with production schedules. In many cases frequency-response (linear) data around the designed operating point is of limited value, whereas studies of start-up procedures, of operating characteristics at off-normal conditions, and of shut-down characteristics are desirable or essential. Further, the operating variables may cover such a wide range that the nonlinearities in the physical equipment must be included in the analog.

A method of developing an analog of a process unit will be described which combines inspection of the system, understanding of the basic physical principles involved, and some relatively simple arithmetic.

The computer used to solve this process problem has the following equipment available:

(a) 120 combination sum-integrate amplifiers
(b) 120 limiter pairs
(c) 48 sum only amplifiers
(d) 28 servomultipliers
(e) 16 photoformer-type function generators
(f) a 1-ampere reference group
(g) 300 coefficient potentiometers
(h) 186 1-μf polystyrene capacitors

Solvent Recovery System

A solvent recovery system is shown in Fig. 1. The steps shown are feed preheating (C_1 and C_2), two stages of flash distillation (C_3, C_4 and E_1), and steam stripping (E_2). Conventional pumps (J's), heat exchangers (C's), vessels (E's), and control equipment are shown.

The control loops are all simple and can be handled by the usual "seat-of-the pants" methods. In fact, there is no point in simulating the operation of this plant, provided ample solvent storage capacity is available. However, it has the disadvantage that steam and water consumption is high. The process engineer can reduce operating costs by recovering as much heat as possible from the several output streams. One of several possible schemes is illustrated in Fig. 2. Here the feedback inter-relationships add a complexity that suggests analysis via simulation.

A Heat-Balanced Solvent Recovery System

The vapor from C_3 is used to warm the feed in C_1, thus eliminating the 10-psi steam and reducing the amount of water needed in C_8. The thermal feedback loop C_3-C_1-C_2-C_3 has *positive* feedback.

If the pressure in E_1 is higher than the boiling point of the liquid in C_3, the vapor from E_1 can be used (instead of 100-psi steam) to heat C_3. This reduces the amount of water needed in C_7. The pressure controller PRC-1 is required to vary the effective condensing surface of C_3. The feedback loop C_3-J_2-C_1-E_1-C_3 also has positive feedback. In addition, there is a transport lag C_3 to E_1.

Use of 10-psi steam in exchanger C_2 can be eliminated by using the hot bottoms from the stripping column. This reduces the amount of water needed in exchanger C_5. The feedback loop C_2-C_3-C_4-E_1-E_2-C_2 also has positive feedback.

The elimination of 10-psi steam to C_1, 100-psi steam to C_3, and 10-psi steam to C_2 results in a large reduction in utility cost. On the other hand, the unit has become more complicated to control. Such a system can be hard to start up, can be sensitive to external disturbances, and can be unstable under some operating conditions. Hence the best procedure is to simulate the

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Presented at Midwest Simulation Council Meeting, February 3, 1958.

complete system so that (1) the start-up procedure can be tested, (2) the "lined out" stability can be tested by using outside disturbances such as steam pressure change or feed composition change, and (3) stability can be tested at different throughputs.

Simulation of Heat Exchangers

The analog circuits for representing a heat exchanger can be made as complicated or as simple as desired. If one tries for mathematical rigor, the analog is hopelessly complicated, with second-order partial differentials that are nonlinear. Important exchangers can be studied in detail but this is seldom necessary. Several factors make such rigor pointless.

From a practical operating viewpoint, the plant should be operable with some of the heat exchangers not in service. In addition, the resistance to heat flow can change by a factor of 2 or 3 between the time of start-up and the time of the next cleaning. Therefore, most exchangers are over-surfaced when clean, and the calculations of heat-transfer rates need only be approximate. With these points in mind we may proceed to look at the exchangers in Fig. 2.

The exchanger C_1 in Fig. 2 has relatively cold liquid flowing through the tubes. Vapor condensing on the outside warms the liquid. The amount of heat transferred to the liquid will be limited by the availability of vapor or by the ability of heat to flow through the available surface. The exit temperature of the liquid also will depend on the liquid flow rate.

For the case where vapor availability rather than surface is limiting, the output steady-state temperature $T_{1\,ss}$ can be calculated by adding the heat carried into the exchanger (by the liquid) to the heat carried in by the vapor as super-heat and latent heat. This total is then divided by the heat capacity of the liquid steam flowing out to give the equation shown in Fig. 3.

However, the maximum $T_{1\,ss}$ is T_2, even for an infinite surface and unlimited amount of vapor. Unless the superheat is very large, the practical limit is the dewpoint T_d. $T_{1\,ss}$ can be computed by a circuit containing two amplifiers and a servo multiplier, as shown in Fig. 3. The steady-state outlet temperature is computed as above but has an upper limit $+T_d - \Delta$. Δ can be made to vary with F_0 to take into account the variation in outlet temperature with load. In the event that T_2 varies significantly, the potentiometer in Fig. 3 that contains T_2 must be replaced by a multiplier. This calculation neglects the subcooling of the condensate and the heat losses to ambient.

A heat exchanger contains time lags. These can be discovered by writing the differential equation for such a device and noting that the time lag is a high order one that depends on the reciprocal flowrates of the fluids through the exchanger. At high flow rates the lags are short, and vice versa. From experiments on the analog, we found that the response to a step input was essentially the same for all lags higher than third order, provided the total RC was the same. From this, there is little point in representing the heat exchanger as higher than third order.

Fig. 4 shows a circuit that produces a variable time lag by using a servo multiplier and three amplifiers.

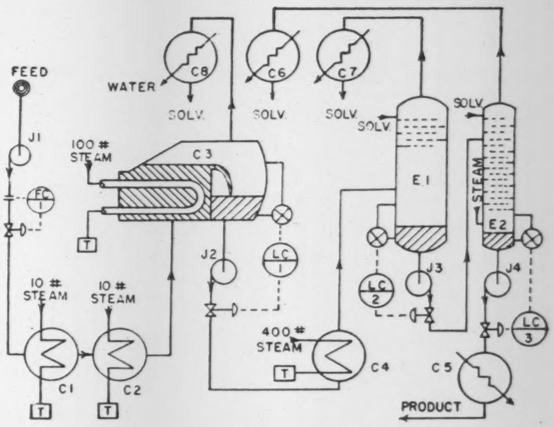


FIG. 1. BLOCK DIAGRAM of simple solvent recovery system.

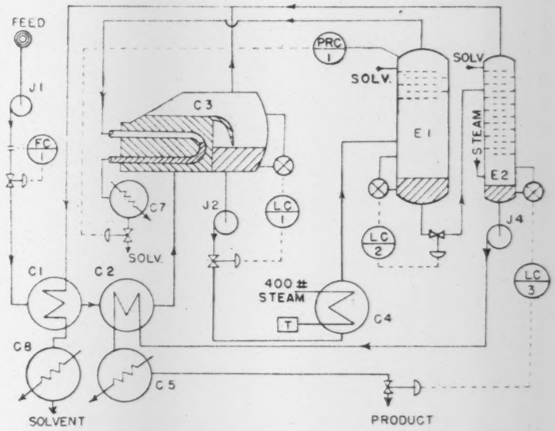
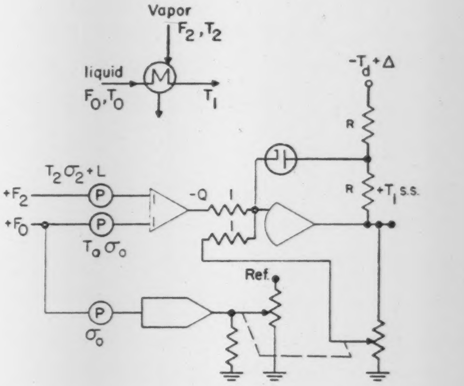


FIG. 2. BLOCK DIAGRAM of improved solvent recovery system that eliminates need for low-pressure steam but presents a control problem.



$$T_{1\text{-}ss} = \frac{F_0\,\sigma_0\,T_0 + F_2\,\sigma_2(T_2 - T_d) + F_2\,L}{F_0\,\sigma_0}$$

FIG. 3. BASIC HEAT EXCHANGER variables, equation, and simulation circuit.

The lag is varied by the flowrate F_0. The capacitors are sized so that the lag at "normal" flowrate is equal to

$$\frac{\text{BTU}/^\circ\text{F for liquid in tubes} + \text{BTU}/^\circ\text{F for iron in tubes}}{\text{BTU}/^\circ\text{F}/\text{sec of liquid flow.}}$$

This same exchanger can be simulated by using a finite difference technique—the exchanger surface is divided into pieces and the heat flow through each piece is calculated. This requires many more multipliers and is not justified except in special cases.

Liquid-liquid exchangers, such as C_2 in Fig. 2, are almost invariably a baffled U-tube bundle in a single shell. A study of the exchanger data sheets for a number of such exchangers showed that the outlet temperatures of the two streams tended to approach each other. The difference in temperature between them was proportional to the sum of the flowrates. This reduces the calculation of the steady-state outlet temperature to a simple heat balance. The circuit for this is shown in Fig. 5.

The time delay in this case depends on the reciprocal of the sum of the flow rates multiplied by specific heats. The circuit is the same as that given in Fig. 4 with the exception that the input to the servo is $(F_0)(\sigma_0) + (F_4)(\sigma_4)$. The voltage Δ in Fig. 5 represents one half the difference in temperature between the two streams. The time-delay circuit may use other cups on the servo multiplier shown in Fig. 5 if the capacitors are properly sized.

The exchanger C_3 is a horizontal evaporator. The temperature on the inside of the non-flooded part of the tube is the dewpoint of the vapor. The temperature of the outside can be considered uniform because of the violent agitation due to boiling. The heat-transfer calculation is then a simple $(U)(A)(\Delta T)$ where U is the heat-transfer coefficient, A is the unflooded area and ΔT is the temperature difference across the tubes.

The area A can be calculated by noting that the amount of liquid in the tubes and in C_7 is given by the time integral of the rate of condensation minus the time integral of the flow rate out of the valve VPRC-1. The flooded surface is proportional to this amount of liquid. The unflooded surface can be found by subtraction of the flooded surface from the total.

Simulation of First Flash Distillation

The boiling circuit for calculating the rate of flow of vapor overhead in C_3 is a simple heat balance with the temperature fixed at the boiling point. The only problem is one of stability of the analog because of time lags in the multipliers. A simple flash distillation by components was simulated assuming ideal solutions and ideal vapors. Integrators were used to keep an inventory of each component in the liquid. A simple weir calculation was performed using the total inventory to get the flow over the dam in C_3.

Pump Simulation

A liquid centrifugal pump, such as J_2, run by a constant-speed motor, or by a turbine with governor, has a steady-state head-capacity curve as shown in Fig. 6. This can be obtained from the manufacturer. The solid curve gives the increase in pressure across the pump as a function of flow through the pump. It is convenient to calculate the pressure drop in the pipe connected to J_2 and subtract this from the pump pressure to get a *net pump pressure*. This function can then be put into a function generator.

Valves and Actuators

The flow through the valve VLLC-1 can be computed from

$$F = C_v A \sqrt{\Delta p}$$

where C_v is a measured flow coefficient for the particular valve. A is the area of opening and Δp is the actual pressure drop across the valve. The area A is obtained from a function generator whose input is valve stem position.

The time lags inherent in valve motors and valve positioners have been measured in the laboratory. Analog circuits, which have been developed for representing these pieces of hardware, are not simple because of the large nonlinearities. These nonlinearities cannot be omitted because they are one cause of saturation oscillations in the plant. We are of the opinion that it is worthwhile to use an actual valve motor and positioner mechanism because the analog is better and the cost of the equipment is much less than the cost of the equivalent computer hardware.

Control Instruments

The characteristics of pneumatic control instruments and tubing have been measured by frequency-response and step-input techniques in our lab. A lumped-parameter delay line has been constructed that gives the characteristics of the instrument tubing when the tubing is terminated in a negligible volume.

The conventional circuits (integrator plus amplifier plus differentiator) do not make a good analog of pneumatic control instruments because the saturations inside the controller are often important, and it is not obvious from a frequency-response plot where to put signal clippers in the analog. We have found it more satisfactory to make a direct analog of the parts inside the control instrument. In this case it is obvious where to put the clipping limits.

We believe it is better, easier, and cheaper to use actual pneumatic control instruments and coils of copper tubing than to simulate these elements. The electric-to-pneumatic transducer required to convert a computer voltage to a pneumatic pressure contains a lag that can be used to represent that of the actual plant transmitter.

Simulation of Pipe Lags

A change in composition in the level pot at the end of evaporator C_3 does not influence the rate of formation of solvent vapors in C_4 until after some time has elapsed. This is not a pure transport lag for several reasons. The flow of fluids is such that the velocity at the center of a straight piece of pipe is higher than that near the wall. In addition, the turbulence produced at elbows and by the pump impeller tend to mix the fluid. Also, the volume holdup in exchanger C_4 introduces a smoothing action. The result is that the pipe can be represented by a high-order lag. The input to the lag is the volume percent of solvent at the beginning of the pipe. The flowrate through the pipe determines the time delay. For instance, low flowrates give long delays while high flowrates give short delays. The circuit shown in Fig. 7 makes use of a servo multiplier and three amplifiers to represent this variable delay. The capacitors are sized so that the delay for normal flows is equal to the volume of the pipe divided by the flowrate.

Second Flash Distillation

The second flash in C_4 and E_1 can be computed on the basis of ideal liquids and ideal vapors to give the rate of flow of vapor up the tower E_1. The solvent reflux is mostly evaporated and goes overhead. The heat for vaporization comes from the superheat in the vapor from C_4.

A simplification tried was to consider the amount of solvent in the bottoms of E_1 fixed at the low average value. In this case the solvent vapor overhead was found by difference. This works as well as the complete flash-distillation calculation in that the control behavior is the same.

Stripping Column

The stripping column E_2 can be considered to be a high-order fixed lag due to tray holdup. The temperature out the bottom can be taken as the steam temperature. All the solvent can be considered to go overhead. This is justified because the solvent in the feed to E_2 is of the order of a few percent, and the bottoms contain solvent on the order of 0.01%.

System Studies

The validity or accuracy of such an analog is difficult to assess. Considerable confidence in these methods can be gained through analog studies of operating units. A detailed comparison between analog results and plant records provides the best evidence of a satisfactory analog.

Analog results on a unit similar to that of Fig. 2 showed that PRC-1 had poorly damped response with a long period of oscillation. A comparison of these results with plant records showed almost identical periods and damping. The proportional band and reset rates found to be optimum on the computer were nearly those in use in the plant.

Tests on the analog showed increasing tendency to instability as the feed rate was reduced. This was in agreement with plant experience. Other tests showed that the control system became more unstable as the percentage of solvent in the feed increased. For pure solvent feed, the system was violently unstable. This result was unexpected, but points out the cause of unexplained upsets in the plant.

Once the plant operator has gained confidence in the analog by looking at the records of the "as built" plant, he is quite willing to accept the predictions of the analog with regard to engineering changes in his plant.

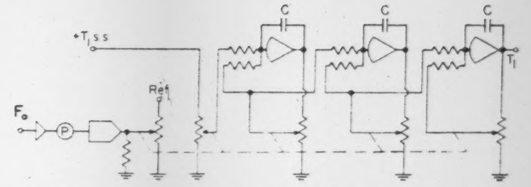


FIG. 4. CIRCUIT FOR PRODUCING a variable lag that depends on flow F_0.

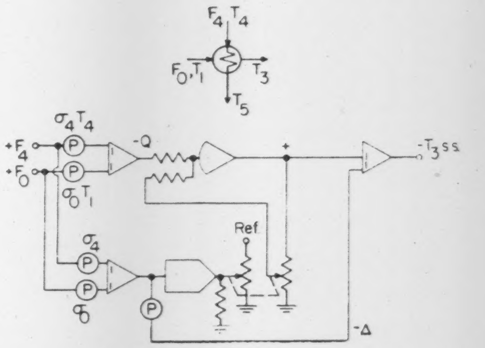


FIG. 5. ANALOG SCHEMATIC for U-tube heat exchanger, based on simple heat balance.

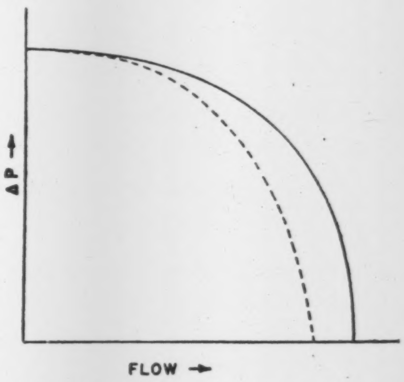


FIG. 6. HEAD-CAPACITY CURVE for liquid centrifugal pump with constant-speed motor; dotted line is net pump pressure after subtracting drop in pipe connected to pump.

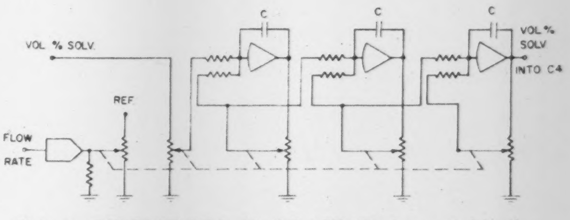


FIG. 7. CIRCUIT FOR SIMULATING the variable delay between change in composition in the level pot and rate of formation of solvent vapors.

Following up the extensive treatment of strain gages in last month's issue, here is a comment on series versus shunt calibration technique for bridge circuits, and a few more representative strain-gage equipments.

Series Versus Shunt Bridge Calibration

E. FRANK, B & F Instruments

THE TWO basic methods for bridge calibration, shunt and series, have relative advantages and disadvantages.

Shunt Calibration

In shunt-calibrated bridge-balance and calibrating units (Fig. 1), the bridge voltage is maintained during the calibrating cycle and calibration is accomplished by shunting a resistor across an arm. Therefore, the strain-gage signal continues to be transmitted to the galvanometer and the calibration pulse is superimposed on this signal.

Series Calibration

In series calibration (Fig. 2), a load-substitution relay de-energizes the bridge just prior to calibration, thus causing the galvanometer to return to zero. The relay also substitutes a dummy load network in place of the bridge to maintain the same voltage drop across the Gain control. Calibration is accomplished by impressing the bridge voltage across one arm of the bridge "in series" with the calibration resistor. The calibration pulse produced by this method always initiates from zero and is a clean square wave regardless of the nature of the original signal.

The magnitude of a calibration pulse caused by a fixed resistor connected "in series" is exactly twice that caused by the same resistor connected in shunt. Therefore, a transducer calibrated with a bridge balance and calibrating unit using shunt calibration always can be used with a unit using series calibration as long as a factor of two is taken into account.

Both methods actually accomplish the same thing. The electrical sensitivity of the circuit from the transducer to the galvanometer is standardized. Any change in the sensitivity due to a change in input bridge voltage, position of sensitivity potentiometer, change in contact resistance or line drop and galvanometer sensitivity can be detected and corrected.

Advantages of Series Calibration

1. Calibration pulse always originates from true galvanometer zero. Data computing apparatus, either manual or automatic, can be adjusted to read from one point for each channel since both calibration pulses as well as signals originate from the same point.

2. Since the bridge is de-energized, calibration pulses are always a clean square wave. Vibratory signals cannot affect the reading of the pulses.

3. Galvanometers will not be driven beyond their linear range during calibration.

Disadvantages of Series Calibration

1. More circuitry is required.

2. Load-substitution potentiometers must be set to match the resistance of the transducer exactly.

3. The magnitude of the calibration pulses does not tell whether someone has changed the setting of the load-substitution potentiometer.

One feature of series calibration which can be either advantageous or disadvantageous is that inherent drift in a transducer is clearly discerned. During the calibration cycle, transducers are de-energized. After the calibration pulse, bridge voltage is again applied and the galvanometers drift from mechanical zero to the equilibrium position. Therefore, though drift is discerned, the records are not accurate until the transducers warm up and the galvanometers come to rest.

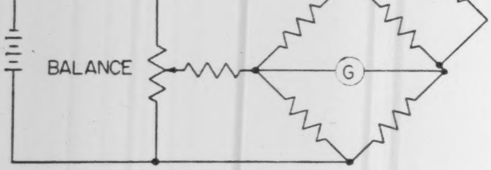


FIG. 1. **SHUNT** calibration circuit.

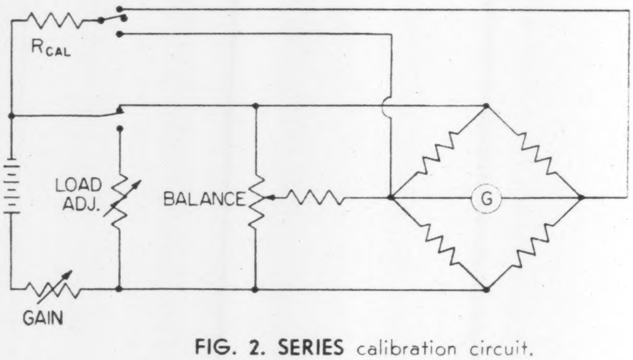
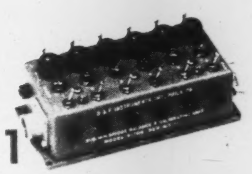
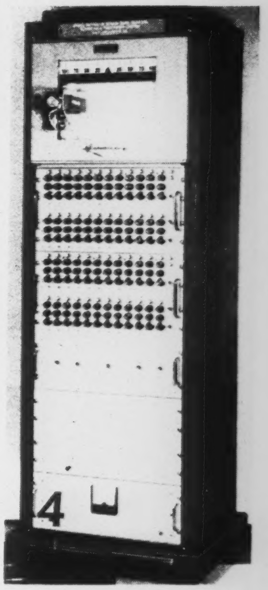
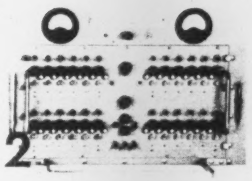


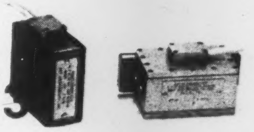
FIG. 2. **SERIES** calibration circuit.

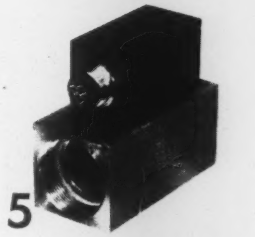
more strain-gage instruments

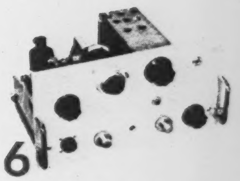


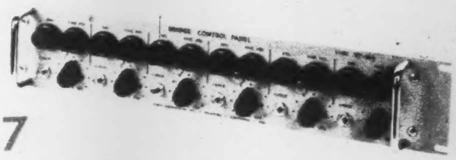












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7 **BRIDGE CONTROL PANEL** BC-266 of Owen Laboratories provides control and operating voltage for six gage channels, with gages of 60 to 100 ohms resistance. Removal of jumper in wiring of each channel permits series instead of shunt calibration (conventional). Auxiliary indicator and calibration panel (IC-260) furnishes balance indicating and calibrating circuitry.

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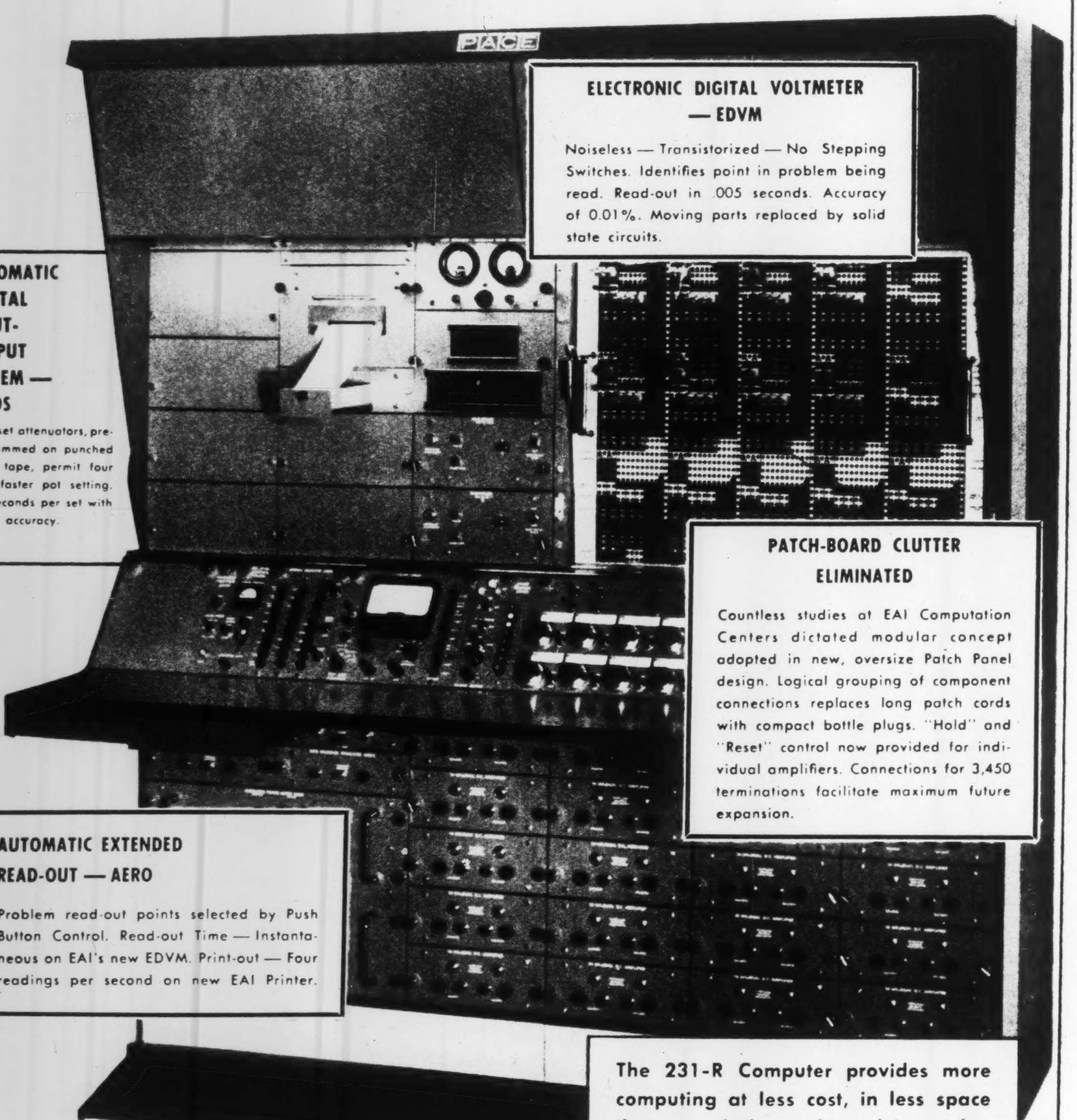

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Dov Abramis, Convair, Pomona, California; Chairman, Steering Committee

Midwestern Simulation Council

Warren Jackson, Jr., Standard Oil Company of Ohio, Midland Bldg., Cleveland, Ohio; Chairman, Steering Committee

Eastern Simulation Council

Hideo Mori, Hydel Inc., 99 First St., Cambridge 41, Mass.; Chairman, Steering Committee

Southeastern Simulation Council

Robert S. Johnson, Georgia Institute of Technology, Atlanta, Georgia; Chairman, Steering Committee

Central Simulation Council

L. R. Freeman, Phillips Petroleum Company, Bartlesville, Oklahoma; Chairman, Steering Committee

Canadian Simulation Council

F. W. Pruden, Analog Computation and Simulation Group, Mechanical Engineering Div., National Research Council, Ottawa, Canada; Chairman, Steering Committee

DDA Council

Stan Rogers, Convair, San Diego, Calif.; Chairman, Steering Committee

Bits

This month under Pieces, I* am happy to report on some of the activities of the DDA Council. As the Digital Differential Analyzer Council is now officially a part of the Simulation Councils, Inc. we hope that we will be able to report their activities regularly.

Also offered this month under Pieces is Jerry Kennedy's slightly twisted (by me) writeup of the Joint Central and Midwestern Simulation Council Meeting on "Process Simulation." Apparently these people have bought (elsewhere) the idea that Milt Aronson and I have tried for years to sell—or give away! Very interesting!

Pieces

DDA COUNCIL MEETING ON Z TRANSFORMS AND DART

At the 15 October 1957 meeting of the DDA Council, *J. V. Howell* (Ramo-Wooldridge Corporation, Los Angeles, Calif.) spoke on the subject of "Z Transforms," and *Loren Meissner* gave the history of the DART Project.

In spite of having taken "a course" on the subject, I do not understand the Z Transform and therefore will not attempt to write about it, in spite of the excellent (I guess) abstract which *Victor Von Praag* wrote. However, I do think Loren's notes on the history of the DART Project are interesting because they describe one of several attempts which have been made (and I hope will continue to be made), to combine the advantages of digital and analog techniques.

As I could not be at the meeting I will just give you Loren's notes as forwarded to me. If you are interested you can get details from the references.

History of the DART Project, by Loren P. Meissner (US Naval Ordnance Laboratory, Corona, Calif.)

1. The DART Project was to some extent a duplication of the work of others—call it poor communication, independent invention, or what you will. It is quite closely related to DIDA (a project at Northrop which predated DART by several years) and to WEDILOG. However, it includes some elements not found in any of the other work. This will become apparent from a description of the history of the DART Project.

2. Early in 1952 a system of "predicting" computation was proposed which would essentially have consisted of separate units for performing conventional digital computing operations on binary numbers in the form of "static" sets of gating-voltages, which could be cabled together "analog-fashion," with the output to be "predicted" far enough ahead to compensate for the computing delays.

3. In a paper at the Pittsburgh meeting of ACM in May 1952, Gordon and Nicola showed how to "multiply" pulse-train information by a "static" gating-voltage binary number. The DART Project was conceived as an extension of this idea to a full DDA, using pulse-trains for integration and static numbers for the other operations, with the conversion between the two types of information taking place in the two "halves" of the integrator. A report was published (NBS 1231, May 1953), and finally in the fall of 1953 the design and construction of the hardware was undertaken by *L. P. Meissner* and *E. O. Codier.* The objective of the project was to build about two integrators and enough other hardware to test the pulse-train portion of the system.

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*Suzy says that "ye Ed." which I would have used here, is corny so I will henceforth use the first person singular (which I ain't—I am neither first nor single).

4. Construction of the first two DART integrators was well under way in January, 1954 when *George Fenn* (who had previously worked at Northrop), visited NOL and mentioned the DIDA Project. Up to that time the objectives of DART were such that we would have done no more than repeat the DIDA Project. In the light of this new information, the objectives were extended to include some hardware for performing "static" operations, using the gating voltages available from the registers of the integrators.

5. The project was terminated at end of April 1954, about seven months after the hardware design was started. Two complete integrators, a dual pulse-train adder, two dual constant-factor pulse-train multipliers, and a monitor integrator (which produced an analog-voltage for recording purposes) comprised the pulse-train portion of the equipment. In addition a static adder with two input half-integrators and an output half-integrator were completed. Total expenditure for the two scientists plus one technician, as well as for supplies, was between $10,000 and $20,000. *"DART Project Final Report"* (Naval Ordnance Laboratory, Corona, Report 172, by L. P. Meissner and E. O. Codier) was published in August 1954.

6. Some pertinent occurrences since the conclusion of this project include:

(a) The announcement of a commercial pulse-train integrator called Wedilog, in 1955 or 1956 (Wang Laboratories, Cambridge, Mass.).

(b) It was pointed out that the "sieve" method of integration as used in DART is *not* equivalent to the "Transfer" method (see Figure 3, NBS 1231, or article by Sprague in MTAC January and April 1952). The "sieve" method introduces large errors in certain cases a horrible example is when y stays at ½ except for counting up and down on alternate pulses (i.e., y alternates between 10000 . . . and 01111 . . .) while dx is full rate.

(c) An apparent awakening of interest since the reference to the DART Project material was published in the minutes of the New York meeting of the DDA Council last spring.

JOINT CENTRAL AND MIDWESTERN SIMULATION COUNCIL MEETING OF 4 FEB. ON "PROCESS SIMULATION."

About 85 representatives of 33 different organizations met on 4 February 1958 at Monsanto Chemical Company's new Research Division in St. Louis, Missouri, to discuss "Process Simulation." The large number of petro-chemical and other process industry representatives shows the growing awareness of this industry in the application of electronic analog computers.

Cooper on Monsanto Simulation

Willis M. Cooper, Assistant General Manager of the Research Division, gave the opening address. After a description of the Research Division and its place in Monsanto, Mr. Cooper described some of the benefits they expect to realize through the use of their 116-amplifier EA computer.

Monsanto's computer is intended for use on process control problems much as analog computers have been used in aircraft and related fields. At the present time, and certainly to a larger extent in the future, the computer will be used on problems involving the chemical kinetics of processes. Through use of the computer Monsanto expects to obtain: (1) increased throughput and product quality, (2) increased labor productivity, (3) improved engineering, (4) new chemical processes, (5) improvement in old processes.

Before the advent of electronic analog computers, the chemical engineer designed the processes on the basis of steady-state calculations. However, chemical processes seldom remain quiescent. They are usually passing up or down through the steady-state point; otherwise little control would be required. The analog computer now provides the chemical engineer with the tools necessary to observe the operation of the process being studied under its normal conditions. Thus the Monsanto computer will be used both to simulate the chemical kinetics of the processes and to solve the equations which completely describe proposed plants.

Miller on Simulation of Paper Mills

Dave Miller told about his company (Colorado Research, a subsidiary of Carrier Corporation) and its entry into the process control field. At present they are concentrating on control and simulation of paper mills. The paper mill is a continuous process which has as input a homogeneous mixture of broken-down cellulose (ground-up logs) and water. This mixture, called white water, flows onto a mesh screen where a portion of the material sticks to the mesh and the remaining white water drops through and is re-entered into the process. Next the screen carries the soft material to a system of rollers and drivers where all the moisture is removed and the paper is pressed to the proper thickness. The final work prior to rolling up the finished stock is a set of steam-heated calendars where the finish is applied to the paper.

The paper moves through the mill at speeds up to one-half mile a minute, so it obviously must be carefully controlled to prevent tearing the stock, and to impart the proper thickness, finish, consistency, etc. Since the nature of the process is analog rather than digital, it is expedient to simulate the elements of the paper mill on electronic analog computing equipment.

The elements of electronic analog computers may be used for actual process control, and may also be used to process raw data into useful information. Dave said that when various transducers (thermocouples, pressure gauges, etc.) yield electrical outputs which are not a linear function of the measured variable, operational amplifiers and function generators can be used to linearize the outputs. Analog computer components may be used to multiply, take roots, generate powers, etc., to yield flow rates and the like in the most comprehensible form. Other data reduction applications involve special computing circuits required to reduce beta meter outputs (unit mass of paper) into the coefficients of a Fourier series to yield the beta meter profiles.

Frequency response tests can be conducted on the paper mill and conventional analog circuits used to yield the auto- and cross-correlation functions of the process. Present methods of doing this are a bit tedious (in that 20 to 30 adjustments may be required to determine a single correlation function) but more automatic techniques are on the way.

Summarizing, Dave said that the paper-industry engineers are looking toward the analog computer for instrumentation, analysis and computation, and control.

Robert E. Henderson (Allison Division of General Motors) asked what kind of a delay generator can be used in the simulation of a paper mill. Dave answered that the use of successive first-order lags generated with integrators is one approach.

William B. Field (Union Carbide Olefins Company) asked whether general-purpose equipment is economical to use for simulating a known process. Dave indicated that general-purpose equipment might be more costly than special-purpose. For instance, if you use an integrator for each first-order lag, you will soon run out of amplifiers. In such case, special filter circuits might be the best approach.

Charles A. Halijak (Kansas State) asked whether, in using correlation techniques, it is ever found that two different processes yield identical correlation functions. Dave replied that he had not encountered that difficulty, yet.

Lewis on Simulation of Solvent Recovery Process

Lloyd Lewis (Standard Oil of Indiana) was the next speaker. Standard of Indiana's Research Laboratory has a general-purpose analog computer consisting of:

(a) 120 combination sum-integrate amplifiers
(b) 120 limiter pairs
(c) 48 sum only amplifiers
(d) 28 servo multipliers
(e) 16 photoformer-type function generators
(f) a 1-ampere reference group
(g) 300 coefficient potentiometers
(h) 186 1-μf polystyrene capacitors

and is currently installing a number of pneumatic and electronic control instruments which will be tied into the general-purpose computer and will be approximately equivalent to an additional:

(a) 170 amplifiers
(b) 20 function generators
(c) multipliers

To use the analog computer to simulate operations of a plant you don't have to write complex differential equations and conduct tedious frequency response analyses of the different elements of the process. The equipment can be set up to approximate the input-output characteristics of the plant, element by element, and then be adjusted to duplicate the characteristics exactly. With such a technique it is important not to overlinearize the simulation because the process must be started from an off-line condition and brought up to an on-line condition. This requires that the process elements operate through a wide range of non-linearities which must be included if the process is to be simulated effectively.

Lloyd illustrated how the analog computer is normally used at Standard of Indiana by describing the steps involved in the design of a simple solvent recovery system which included a feed pre-heating stage, two stages of flash distillation and a steam stripping column. Pumps, heat exchangers, vessels, and control equipment were included in the simulation. Variable transport lags corresponding to pipe lags were simulated by using successive first-order lags varied by servo-driven potentiometers.

Benefits derived from the simulation included reduced operating costs resulting from the recovery of more heat, and improved control which resulted when feedback loops were added to the heat recovery process. The startup procedure was tested on the computer, and stability tests provided additional useful operating data. Results of the simulation were compared with actual tests on the completed process and showed remarkable agreement.

Tests which would have been dangerous on the process were conducted with safety on the computer. Futhermore, some unexpected events occurred on the computer which indicated the cause of several unexplained upsets which had taken place in the plant.

Lloyd said that once the plant operator has gained confidence in the analog by looking at the records of the plant "as built," he is willing to accept the predictions of the simulation with regard to engineering changes proposed.*

Alfred T. Bogen, Jr. (Chemstrand Corporation) asked about improved operation of Standard's plant through using the analog computer. To illustrate, Lloyd said that the flow control valve can now be spun full open, which would have been suicide before better control resulted in such improved plant start-up. They also found that the hot bottoms from one of the columns actually caused boiling in a heat exchanger. This caused high velocities (several hundred feet per second) in one of the lines to an evaporator. They didn't believe the computer results so they made temperature measurements on the plant. These confirmed the simulation and led to improved safety measures.

Ewell A. Clarke (Humble Oil & Refining Company) noted that apparently the complete plant was simulated, including the actual "hold-ups" in the columns. He questioned this, since it uses a lot of equipment. Lloyd replied that it is not advisable to eliminate the hold-up, because of the multiple feedback loops. And to perturbate the process over only a small range from a fixed operating point would be unrealistic because most of their plants operate above their designed capacity.

W. Ovide Webber (Humble Oil & Refining Co.) wondered whether it was possible to simulate more complicated heat-exchangers. Lloyd answered that very complex ones have been studied. They were described by difference equations and tied up the whole computer.

Henry J. Morris (Monsanto) asked how they determined the time delay of a heat exchanger. Lloyd said the total heat capacity of the iron and liquid in the exchanger can be calculated in BTUs per degree change in temperature. The inputs are measured in units of BTUs per second per degree. Dividing one by another results in a time in seconds which is pretty close to the exchanger time delay. If the lags are simulated by a set of successive first-order lags, the lag per stage is equal to the time delay divided by the number of stages.

Lauher on Simulation of a Process Reactor

Verlin Lauher (Monsanto) next described work Monsanto has done on a combination continuous-flow stirred-pot reactor, and the attendant control system. Studies of the reactor stability (both steady-state and transient response) have been worked out in considerable detail, and studies of the servo mechanisms have been developed to a high degree. They felt that much could be gained by studying these areas in combination, so a set of simultaneous differential equations was developed to describe the reactor with coil and jacket cooling. Frequency-response data were obtained for the mixing case (no reaction) and also for the reacting case at the same temperature. For a deviation of temperature of ±10°C around a base temperature of 30°C the process seemed linear. Optimum temperature controller settings for all three modes of operation (proportional, reset, and rate) were determined for the simple mixing case. An interesting result—in no case was derivative control able to increase the stability of the system. In some cases it actually reduced effectiveness of the control.

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*Lewis' paper is included in the feature articles in this issue. Ed.

Asked by *Oride Webber* if he had considered inverse derivative, Verlin said no.

Dr. Lewis observed that dead time in a system can be thought of as equivalent to a very-high-order lag. All the addition of derivative control does is reduce the order by one, which doesn't help much.

William M. Borman (Armour Research Foundation) noted that the controller set points were calculated by allowing a certain number of oscillations for the system to damp out, and asked if the sensitivity of the system would be affected markedly if the number were increased by one. Verlin answered that it would not.

Madigan on Analysis of a Pyrolysis Process

James F. Madigan (B. F. Goodrich Co.) was the next speaker. The group that Jim works with is interested in the development of new chemical processes, and Jim is specifically interested in design. The equations used in an analog-computer investigation of the continuous pyrolysis of material in a tubular reactor were developed by David Miller when he was at the Berkeley Computation Center. A pilot plant was in operation, so results could be checked, but as it was undesirable to disturb the pilot plant the simulation was adjusted to match it at several operating levels and then used to explore extreme conditions.

In the process heat is transferred into the tube at a varying rate, and the reaction at any point proceeds at a rate dependent on the temperature and composition at that point. During the study tube diameter, rate of flow, and furnace temperature were kept constant. To simulate the reactor under these conditions, thirteen amplifiers, seven multipliers, four function generators, and eleven potentiometers were used. Tube length was represented by time in the computer. The object of the study was to predict the reactor length which would result in a 97% conversion under various operating conditions. After the computer was matched to the pilot plant at several points and sufficient correlation was achieved, 58 experimental runs were simulated and the conversion and temperature profiles were recorded. By extending the study a true optimum design (in terms of equipment cost, feed conversion, and yield of desired and byproduct) could be determined.

Clymer on Computer Data Preparation By Implicit Synthesis

Ben Clymer (North American Aviation, Inc., Columbus, Ohio) spoke next on the broad concept of preparing data for the computer based on physical system tests. Basically, system synthesis by dynamic implicit computation is a method which will yield constants and functions in sets of differential equations which cannot be determined theoretically. This method appears to have tremendous potential in the process industry and other fields where physical systems are in operation but are not fully described in mathematical form. The methods outlined in Ben's paper apply equally well to operational-amplifier analog, passive-element analog, digital differential analyzer, and general-purpose digital computers.

Implicit synthesis consists of the use of an implicit circuit (i.e. "forcing" circuit) to determine and display one or more of the desired characteristics in the differential equations for a system, given the rest of the terms in the differential equations, as well as the dynamic response of the system to some arbitrary excitations which exercise the dependent variables over their full ranges. The implicit circuit contains a mechanization of a differential equation which is complete except for the unknown characteristics. The missing characteristics are synthesized by the implicit circuit by continuously comparing the values generated for dependent variables with the experimental time histories of the dependent variables, and greatly amplifying the differences.*

Implicit synthesis is thus a distinct mode of application of computers. It differs from the usual mode of application, in which the differential equations and the excitation are known and the solution (the value of the dependent variable as a function of the independent variable) is desired. By contrast, in implicit synthesis the solution and the excitation are known but one or more unknown characteristics of the differential equations must be determined.

Much more common than implicit synthesis as a technique at present is manual trial-and-error setting of the potentiometers in an implicit analog circuit in order to match by eye or by minimum-error criterion a given time history of a dependent variable. Implicit synthesis is superior due to (1) greater speed, (2) less error, (3) elimination of several possible causes of mistakes by removing the human operator from the loop.

Ben showed examples of implicit synthesis on first- and second-order differential equations, and a chemical kinetics problem using an electronic analog computer. He also described the application for an IBM 704 digital computer. Stability, noise, accuracy, transients, scaling, and other pitfalls and limitations were discussed. All in all, this was a highly interesting paper and supplied food for thought in expanding the applications and uses of computers. In summary, it might be said that computers have usually been used to determine the answer when the system is described; now implicit computation may pave the way for determining the system when the answers are known.

The Monsanto Facility

Following Ben's talk the Monsanto analog computer (under the direction of *Dr. T. J. Williams*) was exhibited, and three sample problems were demonstrated by *Ollie Sullivan* (Electronic Associates Inc., Dallas, Texas). The computer consists of the following equipment:

3 control consoles
116 operational amplifiers
23 servo multiplier/
function generators
240 potentiometers
3 strip chart records
3 X-Y plotters

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*In other words, this is a feedback system in which the difference between the simulated and measured outputs is used to adjust the value of the unknown exponent to drive the difference toward zero. Ed.

The first problem demonstrated on the computer was the simulation of product conversion in a tubular reactor where tube length (time on the computer) was the independent variable. This was similar to the example discussed in Jim Madigan's paper.

The second problem involved a compressor model with gas pressure inside the cylinder as a function of the volume, gas constant, discharge pressure, and suction pressure. The PV diagram was displayed on an X-Y plotter.

The third was a linear-programming problem which concerned the blending of two grades of material being confined to yield a product having certain specifications. The computer was programmed to determine the proportion of each material so that specifications could be met at minimum cost. These proportions were displayed on an X-Y plotter, and it was interesting to observe the computer output as the minimum cost condition was sought.

Information (Without theory)

We have a letter from the Bureau of Technical Information (38 Farringdon Street, London, E.C.4, England) which says in part:

"We have decided to issue a monthly bibliographical bulletin on computers. Iota Services Limited, with its highly specialized staff, regularly scanning and abstracting the world's technical literature, is particularly well qualified to undertake this work.

"The Bulletin, published on the first of each month, will provide the only complete record available of everything published in this country and overseas on computers, fully annotated with all bibliographical details. Books, articles, technical films, patents, meetings will all be covered, in addition to reports, exhibitions and all trade literature.

"In scope the Bulletin will deal generally with design, analogue, digital, and converters. Specifically every application of computers will receive detailed coverage: aeronautical, business, electrical power, machine tool control, nuclear, production and process control, rolling mills, transport and miscellaneous."

Price of a year's subscription is £6. 6s.

Computer Events

AIEE—Committee on Computing Devices

Date: Monday morning, 5 May 1958

Place: California Institute of Technology, Pasadena, Calif.

Western Simulation Council and DDA Council

Date: 5 May 1958, 1:30 PM

Place: California Institute of Technology, Pasadena, Calif. Pasadena, Calif.

Subject: "Problems Unique to Computers of a Kind"

The meeting will be unclassified. Further information from Stan Rogers, Cypress 6-6611, Ext. 1657, San Diego.

Western Joint Computer Conference

Dates: 6-9 May 1958

Place: Ambassador Hotel, Los Angeles, California

Subject: "Contrasts in Computers" Sponsored by IRE, ACM, and AIEE.

Midwestern Simulation Council

Date: 9 June 1958

Place: North American Aviation
4300 East Fifth Avenue
Columbus, Ohio

Subject: "Cute Tricks in Simulation"

For further information check with Jerome D. Kennedy, Secretary of the Midwestern Simulation Council, c/o Electronic Associates, Inc., 101 South Pine St., Mount Prospect, Illinois.

Computer Clinics, Fourth International Automation Exposition

Dates: June 10-13 1958

Place: Coliseum, New York

Subjects: 90-minute lecture—demonstrations on various analog, digital, DDA, and symbolic logic techniques. For info write Rimbach associates, 845 Ridge Ave., Pittsburgh 12, Pa., or see page 614.

Association for Computing Machinery—Annual Meeting

Dates: 11-13 June 1958

Place: University of Illinois, Urbana, Ill.

Denver Research Institute

Dates: 24-25 July 1958

Place: University of Denver, Denver, Colorado

Subject: Fifth Annual Symposium on Computers and Data Processing

The symposium will emphasize Formalized Analysis Techniques, Systems Organization, Logical Design Techniques, Automatic Programming, Components and Devices, Digital Communications.

For more info write C. A. Hedberg, Head of the Electronics Division, Denver Research Institute, Denver, 10, Colorado.

Association Internationale pour le Calcul Analogique

Dates: 1-9 September 1958

Place: Strasbourg, France

Subject: "Journées Internationales de Calcul Analogique"

An exhibit of analog equipment will open 30 August and continue until 10 September. Because of the increasing interest in the combination of analog and digital techniques, a section of the "Journées" will be devoted to this subject. For further information write Monsieur F. H. Raymond, 138 Boulevard de Verdun, Courbevoie (Seine), France.

1958 National Simulation Conference

Dates: 23-25 October 1958

Place: Dallas, Texas

The conference will be sponsored by the IRE Professional Group on Electronic Computers and the Dallas Section of the IRE. For further info write Louis B. Wadel at 3905 Centenary Drive, Dallas 25, Texas.

Sie sind herzlich eingeladen, den 4. internationalen Automation-Kongress und die damit verbundene Ausstellung vom 9. bis 13. Juni 1958 in New York zu besuchen.

Vous êtes cordialement invité à visiter la Quatrième Exposition Internationale de l'Automation et à participer au Congrès qui auront lieu à New York, du 9 au 13 Juin 1958.

Wij hebben het genoegen U uit te nodigen tot een bezoek aan het Vierde Internationale Automatie Congres en aan de tentoonstelling in New York, van 9 tot 13 juni, 1958.

Temos o prazer de convidar V. Exa. a visitar o Quarto Congresso e Exposição Internacional de Automatização, em Nova York, de 9 a 13 de Junho, 1958.

Invitamos a usted cordialmente a visitar el IV Congreso y Exposición Internacional sobre Automatismo que tendrá lugar en Nueva York los días 9 a 13 de Junio de 1958 .

La S.V. è cordialmente invitata a visita la Quarta Esposizione Internazionale di Automazione che avrà luogo in New York dal 9 al 13 giugno 1958.

Ni är hjärtligt välkommen att besöka den Fjärde Internationella Kongressen och Utställningen om Automation i New York den 9-13 juni 1958.

Pyydämme ystävällisesti Teitä tutustumaan Neljänteen Kansainväliseen Automatisointikongressiin ja sen yhteydessä järjestettävään näyttelyyn New Yorkissa 9.6.-13.6.1958.

De indbydes venligst til at besøge den fjerde internationale Automation Kongres og Udstilling i New York den 9-13 juni 1958.

Σᾶς προσκαλοῦμεν ἐγκαρδίως ὅπως ἐπισκεφθῆτε τό 4ον Διεθνές Συνέδριον καί τήν Ἔκθεσιν Αὐτοματισμοῦ τῆς Νέας Ὑόρκης τῆς 9 - 13 Ἰουνίου 1958 .

9-13 Haziran 1958 tarihlerinde New York'ta toplanacak olan Milletlerarası 4'ncü Otomasyon Kongre ve Sergisini ziyarete teşrifiniz rica olunur.

Srdečně Vás zveme na čtvrtý mezinárodní kongres a výstavu automatisace v Novém Yorku, 9.-13. června 1958.

Uprzejmie zapraszamy na IV Międzynarodowy Kongres i Wystawę Automatyzacji w Nowym Jorku w dniach od 9 do 13 czerwca, 1958 r.

茲訂於一九五八年六月九日至十三日在
紐約市舉行第四次國際自動機械儀
器研究展覽會敬請
光臨
第四次国際自動機械儀器研究展覽会謹訂

TISZTELETTEL MEGHIVJUK ÖNT, HOGY LÁTOGASSON EL AZ 1958 JUNIUS 9 ÉS 13 KÖZÖTT, NEW YORKBAN RENDEZENDŐ NEGYEDIK NEMZETKÖZI AUTOMATIZÁLÁSI KONGRESSZUSRA ÉS KIÁLLITÁSRA:

Srdačno se pozivate da posetite Četvrti Medjunarodni kongres i izložbu automatizacije koji će se održati u New York-u od 9-13 juna 1958 godine.

Sunteţi călduros invitaţi să vizitaţi cel de al IV-lea Congres Internaţional de automaţie şi Expozitia ce va avea loc in New York între 9-13 iunie,1958

הננו מתכבדים להזמינך בזה לקונגרס הבינלאומי
הרביעי ולהתערוכת מיכון אבטומטי אשר יערכו
בניו יורק ב9 - 13 ביוני 1958."

Вы любезно приглашаетесь посетить 4-й Международный Конгресс и выставку по автоматике, которые состоятся в г.Нью-Йорке с 9 по I3 июня I958 года .

आपसे सानुरोध प्रार्थना है कि न्यू यौर्क में, ९ से 13 जून तक होने वाले, स्वयं-चालक यन्त्रों के चतुर्थ अन्तर्राष्ट्रीय प्रदर्शन को देखने के लिए अवश्य पधारें।

TRANSLATION

"You are cordially invited to visit the Fourth International Automation Congress and Exposition, New York, June 9-13, 1958."

See insert opposite, and also page 614 for show and meetings details.

This is

YOUR TICKET

registration card
and badge

DO NOT MAIL

See instructions reverse side

SHOW HOURS

2 to 9 PM, Monday through Thursday, June 9-12, 1958

2 to 6 PM, Friday, June 13

THE EXPOSITION MANAGEMENT

invites you to attend the "Show of the Future"

Designed to give a concentrated picture of the potentialities, techniques, and equipment available, the Fourth International Automation Exposition and Congress will encompass all the elements of decision, product, and technique for application in industry, defense and research.

FOURTH INTERNATIONAL
AUTOMATION
EXPOSITION and CONGRESS

EXPOSITION CAPITAL OF THE WORLD
New York COLISEUM
JUNE 9 - 13, 1958

YOUR INVITATION TO...

THE SHOW

Displays will feature automatic control systems, digital and analog computers, automatic inspection and testing devices, communication systems, feeding and work positioning mechanisms, machine controls, and electronic, electrical, mechanical and electromechanical components.

EXHIBITOR CLINICS

Clinics sessions will comprise 1½-hour classes held in front of operating equipments. Only limited attendance is possible at each class. Advance registration will secure those classes desired by any individual. Fee is $1 per class; registrant must select 2, 4, 6, or 8 classes. Two are given each day. See other side this sheet for registration form and list of exhibitors planning clinic sessions. More will be added.

TECHNICAL SESSIONS

Especially designed for engineers and executives responsible for automation, each session will include from two to four papers presented by authorities in each field. See list of sessions and registration form other side of this sheet. Fee per session is $1.00.

COOPERATING SOCIETY

The ASME Materials Handling Division has scheduled four sessions whose theme will be "Materials Handling as a Key to Industrial Automation." They include: Automatic Warehousing; Automatic Materials Handling Systems in Small Plants and Warehouses; Automation on the Production Line; Systems Engineering, Economy and Justifications. Fee for the 4 sessions is $2 for ASME members; $5 for nonmembers. See other side this sheet.

CONFERENCES

Special Executive Conferences lasting two days—four sessions each, include: Human Factors in Systems Engineering (cosponsored by Manhattan College); and Plant Layout for Automation (cosponsored by Plant Layout Technical Workshop of Oakmont, Pa.). Fee for each Conference is $75.00 Accommodations are limited; early reservation is advised. For details write to Richard Rimbach Associates, 845 Ridge Ave., Pittsburgh 12, Pa.

Use TYPEWRITER or print LEGIBLY. Fill in card and stub COMPLETELY, and bring it with you to the Registration Desk at the Coliseum, 1 Columbus Circle, New York City. DO NOT MAIL THIS CARD.

This card for SHOW admittance only, NOT for Clinics or Conferences.

Hours—2 to 9, Monday thru Thursday; 2 to 6 Friday; June 9 to 13, 1958

Your Name ....

Title ....

Company Name ....

Co. Address (STREET) ....

City.............................. Zone State

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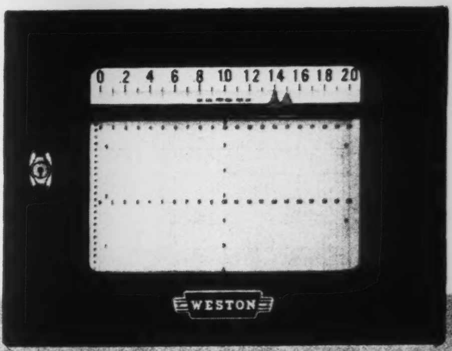

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Industrial Instruments

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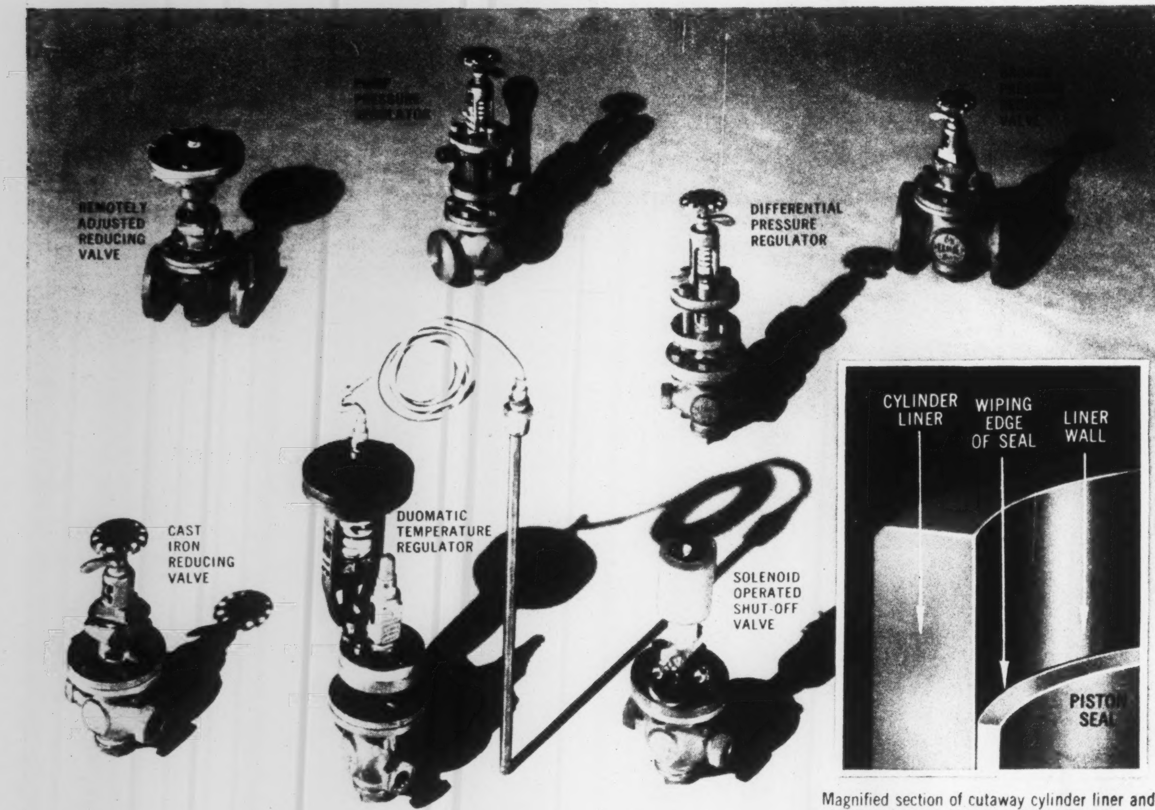
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Magnified section of cutaway cylinder liner and piston seal demonstrates self-cleaning action at point of contact between seal and liner. Liner wall is swept clean of contamination deposits.

. . . another LESLIE Quality First!

REGULATORS WITH SELF-CLEANING PISTONS

. . . at no extra cost

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Journal of the S C M A . . .
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ELIMINATING NOISE AT GAS METER STATIONS

R. C. LISK
Fisher Governor Company

Identification and elimination of noise-producing vibration at pipeline terminals pays off in longer life for equipment, improved employee performance, and better public relations.

NATURAL GAS, as it comes from the well, is usually dripping with related hydrocarbons such as propane, butane, etc. Gasoline plants close to the point of production can recover the valuable natural-gas liquid byproducts while preparing the natural gas for market.

Gas often appears at the wellhead at considerable pressures—sometimes several thousand psi. Such pressures represent a tremendous reservoir of energy. Unfortunately, about the only use which can be made of this energy is to move the material from the wells to the gasoline plant. The greater part must be dissipated to reduce pressures to a level which can be tolerated by the containers and processes of the gasoline plant.

Once cleaned and dehydrated, the gas is delivered to the transmission lines at pressures too low for economical transportation. In order to keep pipelines within a practical size and yet carry the billions of cubic feet necessary, the pressure must be boosted back up. Part of the gas energy is consumed to start it on its way. Furthermore, friction in the pipeline takes a toll, and booster stations about every 50 miles must consume more energy in order to keep the gas moving.

When the gas arrives at the point of use, it is reduced to a fraction of the pipeline pressure and another energy dissipation occurs. The process sounds wasteful, but the ratio of energy consumed to energy transported is not large.

MAY MEETING: Thursday, the 15th, Rio Hondo Country Club.
FEATURE: To be announced.

Metering

From well-head to burner tip, natural gas is usually measured three or more times—(1) when the producer sells it to the transmission company, (2) when the transmission company sells it to the distributing company, and (3) when the distributing company sells it to the ultimate consumer.

Gas is commonly measured by either positive displacement meters or orifice meters; the orifice meters at the transmission terminals (located usually at the town border stations) are our primary concern. The flow through the orifices is variable and determined by the homes and industries connected to the distribution system. At such stations the variable transmission pressures (as high as 1000 psi) are reduced to a constant metering pressure by the pipeline company and then to a still lower pressure as determined by the contract between the pipeline company and the distributing company.

Such town border stations are often close enough to residential sections that any noise from mechanical vibration accompanying the pressure reduction can be objectionable.

Fig. 1 is a schematic showing a high-pressure reducing and metering station. This is a two-stage, two-tube station reducing the 300- to 700-psi transmission

TABLE 1—COMMON NOISE-FREQUENCY BANDS.

No.	Description	Frequency CPS
1.	Rumble	30-60
2.	Howl	400-1500
3.	Hish	1500-3500
4.	Squeal	3000-7000
5.	Ultrasonic	20,000-Up

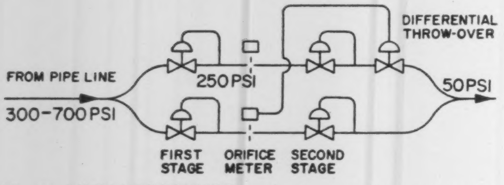

FIG. 1. HIGH-PRESSURE reducing and metering station.

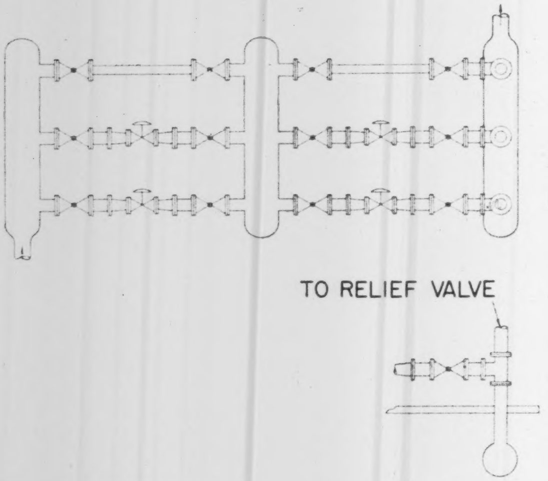

FIG. 2. SCHEMATIC of a noisy metering station.

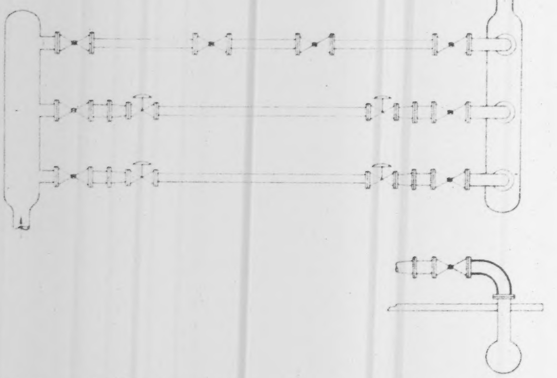

FIG. 3. TAKING "HISH" OUT of a noisy station by eliminating the header.

pressure down to a constant 250 psi for metering. When the differential across one tube reaches a predetermined maximum, the meter-run valve in the other tube opens automatically and parallel measurement handles the increased load. After measurement, the pressure is reduced to the contract value of, perhaps, 50 psi before delivery to the gas utility.

The energy dissipated in such a station can be enormous. A 6" double-ported regulator, reducing from 700 psi to 250 psi, has a capacity of some 10,000,000 cu ft per hour, equivalent to some 500,000 pounds of gas per hour. Although a great deal of energy dissipation is accounted for in expansion, a great amount also gets side-tracked in impact, absorption, and mechanical vibration of pressure-regulator parts and manifold piping.

These side effects cause noise, and these audio frequencies are projected to the surrounding air. The resulting vibration and noise can (1) cause failure of the regulator or associated pipe and fittings, (2) annoy a community to action against an attractive political target, the gas company, and (3) make maintenance and chart changing an unpleasant experience.

Noise Analysis

Table 1 shows the sounds that can result from the mechanical vibrations in a pressure regulator manifold.

Rumble, the lowest frequency, results from small movements of the regulator inner valve not connected with the actual job of changing flow rates.

Howl (400 to 1500 cps) is the result of piping and fittings vibrating in response to the high-velocity impingement of gas. This howl not only contributes to the noise spectrum but also promotes fatigue failures of welds and materials.

Hish (1500 to 3500 cps) can be at such a level as to call down the wrath of the town council and evoke complaints from the service department. This noise is usually from abrupt transitions in piping size and in expansion chambers.

Squeal (3,000 to 7,000 cps) appears when one or more of the parts in a pressure-reducing station decides to vibrate at its natural frequency and draw energy from the flowing gas to support that activity. This can produce a pure tone component of irritating magnitude. The offending part can be one of the components of the manifold; in a few cases it is the inner valve in the pressure regulator.

Ultrasonic noise gives the dogs a bad time and may have other mischievous results, such as breaking light bulbs, loosening tubing connections and flange bolts, and beating up stem connections on pressure regulators.

Remedies

The schematic of a large metropolitan border station is shown in Fig. 2. Here noise reduction became imperative as the gas through-put was increased. Nearly every noise category in the book existed at this location and the manifold quivered as if it might take off into outer space.

An audio meter and frequency analysis isolated a distinct rumble. This rumble was traced to nervous vertical movements of the regulator inner valves. While these movements can be corrected by several means (such as suppression by additional air and spring loading on the regulator, or reduction of inlet mass velocity), the means employed for positive results was a liquid dashpot. The elimination of parasitic inner-valve movements gave a reduced noise level in the rumble range and a steadier set of piping.

The next step was to isolate and evaluate the "hish." It centered around the large cross-over header, commonly called a "log," between regulator stages. As shown in Fig. 3, the header was removed. The noise level dropped from 112 db to 93 db and it became possible to stay near the station. Also, heavier pipe was installed downstream of the regulators than was required for reasons of pressure only. This is important in suppression of noise in the "hish" category.

Long-radius ells will be substituted for the right-angle turns, and it is believed that another significant reduction in sound level will result.

While this station was not troubled with "squeal" noise (3000 to 7000 cps), nevertheless this type of high-pitched pure-component noise can be a problem. A good point to investigate is the possibility of interaction between that noise and the resonant frequency of the regulator inner valve.

Fig. 4 shows a regulator inner valve driven by laboratory equipment at its resonant frequency, with a sand pattern indicating the low-amplitude areas. Resonance in this case is quite sharp at 3200 cps, in the lower end of the "squeal" range. Results of fatigue induced by this vibration phenomenon are shown in Fig. 5.

When the sound equipment points to the regulator as the likely source of this vibration, the remedy corrects both the hazard of inner-valve failure and the unpleasant, high-pitched squeal.

A logical approach would be to change the natural frequency of the valve to render it insensitive to transitory driving forces. In most cases, "beefing" the valve up (using a solid casting rather than a bell-like unit), and departing from symmetry will accomplish wonders. The added mass and non-symmetry of the valve shown in Fig. 6 change the natural frequency and make it harder to resonate.

Noise Research

Although regulators have been vastly improved from a noise-suppression standpoint, there still remains the important and fruitful job of redesigning the entire metering station to achieve minimum noise and vibration levels. This will require rather extensive and expensive research, including building of test stations to be operated under controlled conditions.

When this is done, it will be wise to avoid the constructions shown in Fig. 7. These can be found in the conventional high-pressure reduction and metering station, and all cause excessive mass velocities at regulator inlets, manifold piping vibrations, unstable metering, and the undesired "noise."

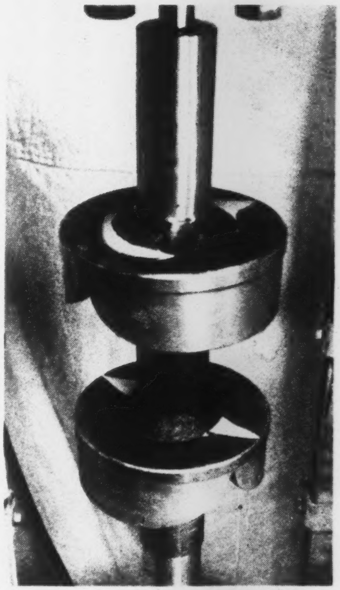

FIG. 4. RESONANCE SAND pattern of a regulator inner valve.

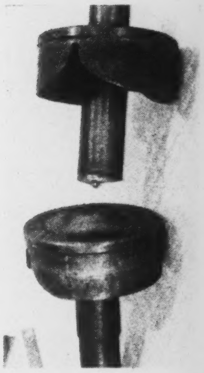

FIG. 5. FAILURE induced by audio vibration.

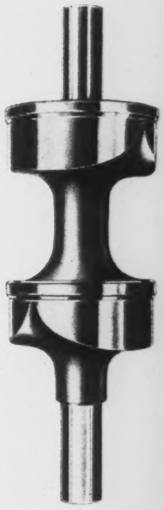

FIG. 6. INNER VALVE design with added mass and non-symmetry.

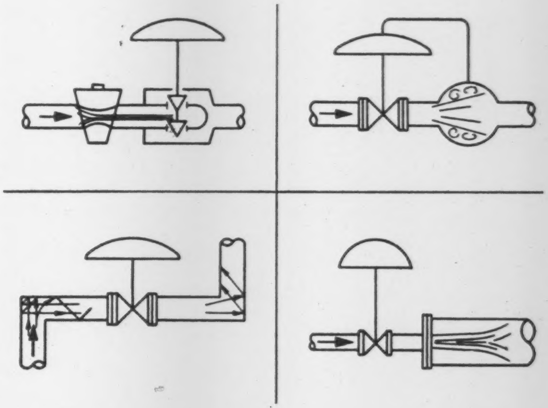

FIG. 7. CONFIGURATIONS to be avoided.

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Unique in moisture-control, Van-Air Dryers do more than trap condensed liquids from compressed air lines. They remove vapor-humidity to *LOW DEW POINTS* besides eliminating water and solid impurities from raw compressor air.

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Panhandle Pete

Introducing the T. L. System

As all you avid readers know, WESCO!'s champion Instrument Salesman has just sold the first System job in the history of the company and, to discover the impact of this juicy piece of business on WESCO!, I thought I'd better go see Mr. J. L. "Bus" Wallace, Chief Engineer. After all, it is the pleasant duty, nay, the responsibility, of *Instruments and Automation* to bring forth all new developments to the trade each month. You readers don't want to remain ignorant, do you, and find yourselves in the position one of our readers is—he's been reading *I&A* magazine for 28 years and now understands 25% of it whereas originally he understood 75%. (Wonder if my writings have had anything to do with this?)

Anyhow I thought I'd get J. L. and maybe snoop around the factory and see if the boys are just chopping wood—not burning it. So I drove over to his office and managed to catch him just as he was leaving for the Branch Factory at Long Bottom.

"My gosh," he says. "We've really got ourselves in a sweat this time! For once we are all set to throw away a lot of money and turn our surplus into a big, fat, deficit. If it hadn't been for that idiotic salesman selling a Systems job—Hell's fire, we don't even make such a thing yet. And I got a wire from Klapsaddle yesterday that this simple salesman has promised two week's delivery."

"Stop worrying," says I. "All we need is money and personnel. Let's call a meeting to see where we will get these two minor items."

As Bus and I entered the office, we stumbled over the body of our Salesmanager, Waldo Klapsaddle, lying on the floor. Waldo was operating the astounding Model O. J. Computer with one hand while with the other he was printing designs on the floor with the bottom of a wet beer bottle.

"Klapsaddle, you're fired!" yelled Bus. "And . . ."

"Now wait a minute, Cuz," said Waldo with a big fat grin. "Everything is OK now. Why don't you and Cuz set down a spell—Hey Penelope, bring these Cuzes a glass of ramp juice—and hear what's happened?"

Being overpowered by his logic as well as by the smell of ramps, we both collapsed on the office sofa.

"First of all, Cuz, to build this here Three-Loop System we have to have money, lots of it, see; so who stumbles in here today but that there guvermint feller we sold all them Unguided Missiles to—with orders to renegotiate our bill for $10,365,264.14. But when he heard we were in the Systems Engineering business he said we would need every penny of it, and he okayed the bill. Then I says we have to have some place big to build and develop these systems things and this guvermint feller says that there is an old zeppelin hangar out at Akron, Ohio."

"For the hired hands to work on this System stuff, I've called up on my old almy mammy, The Gilbert Hall of Science, and they have guaranteed to have 8 system engineers down here the first of the month, and all we have to do is promise them fancy titles with low pay."

"Where are they going to get all these systems engineers?" counters Bus.

"Easy," says Waldo. "A systems engineer is only a young fella not out of college long enough to forget his calculus. Each of these boys has been given one MIT book to read; so that makes them systems engineers. So you see, all our money and personnel problems are solved."

With all this, Bus's eyes lit up and his lips moved in a silent recital of Milton H. Aronson's definition of "Automation." "Only two things still worry me, Klapsaddle: what about this purchasing agent who is pestering you—and do we have a trademark for our System?"

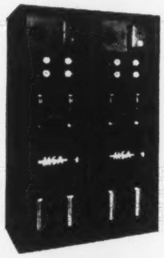
"Ah shucks Cuz, them's easy. Me and him got to talking together over the phone and we found out his great grandfather married my wife's grandmother's third cousin and that makes me and him kinfolk. He ain't going to give us any trouble now."

"Trademark? That's easy too. Look at this here floor. See all designs with three circles hooked together? Perfect! The WESCO! Three-Loop (T. L.) System. What, Cuz, you say a brewery already owns that design? We'll just have to buy them out. The model T. L. System is on the way!"

Panhandle Pete

M-S-A (LIRA) Infrared Analyzer (Model 200)

Low-cost deflection type unit for automatic, continuous, high speed, accurate analysis. Detects one component in a simple or complex mixture of gases or liquids. Unitized construction makes maintenance easy. All controls readily accessible on front panel. Write for details.



M-S-A Carbon Monoxide Analyzer

Single or multipoint cabinets designed as alarms or recorders are available for detecting or measuring low concentrations of carbon monoxide in air. Measurements are based upon measurement of heat of oxidation when sample is drawn through granular catalyst. Write for details.

M-S-A Combustible Gas Analyzer

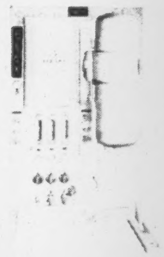
Adaptable for use with any gas or vapor of which the explosive range, and molecular weight are known. Applications extend to all industries where combustible fluids are employed. Now available with remote filament heads specifically adapted to high temperature applications. Write for details.

M-S-A Gas Thermatron

Simultaneously uses thermal conduction and thermal convection to provide simple, accurate, physical measurement of a single component in a complex mixture of gases without interference from other constituents. Can be used in many gas mixtures. Write for details.

M-S-A Oxygen Indicator

For precise, continuous measurement of oxygen content of inert and combustible atmospheres in chemical, metallurgical and petroleum industries. Provides means for improving safety of utility operations and controlling pipeline corrosion. Write for details.



M-S-A Water Vapor Recorder

Detects trace moisture in air or gas streams. Operation is based on measurement of the heat energy exchanged when a gas is adsorbed on or desorbed from the surface of a solid adsorbent. Can be calibrated for various ranges from 0 to 10 parts per million up to several percent. Write for details.

This line-up of M-S-A® Gas Analyzers can help solve your process stream problems

M-S-A Gas Analyzers have earned a sound reputation for on-stream accuracy and dependability while solving a myriad of complex control problems. Chances are, some of the problems confronting you now have already been solved for others, with one of the basic units described above.

The experience and service we can bring into play may provide the breakthrough you're looking for in successful process stream control. Our thirty years in the business of gas analysis instrumentation are worthy of your consideration. Get in touch with an MSA Instrument Specialist for details, or write for helpful literature.

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INSTRUMENT DIVISION

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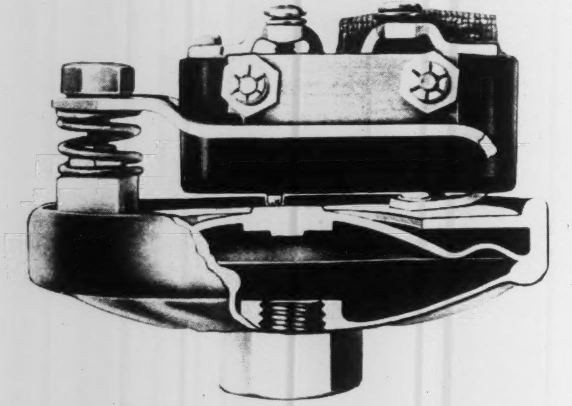
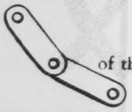
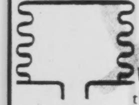
NEW PRESSURE SWITCH FOR THE O.E.M.

This *stripped* switch is designed specifically for the Original Equipment Manufacturers who enclose the various controls in a common cabinet. This new pressure and vacuum switch model 402, incorporates the same dependable accuracy and other operating features of the proven *housed* model 420.

Cost and price have been cut by eliminating the housing.



HERE'S THE SIMPLEST DIAPHRAGM PRESSURE SWITCH

WE BUILD IN	WE DON'T USE
EXTREME ACCURACY and DEPENDABILITY maintained during entire operating life due to direct acting design.	 LINKAGE and BEARINGS because wear causes the setting of the pressure switch to drift.
EFFICIENT OPERATION IN ANY POSITION which saves the installation costs encountered in mounting a switch using liquid switching elements.	LIQUID SWITCHING ELEMENTS because they make the switch difficult to mount and very critical to vibration.
IMMUNITY TO VIBRATION allowing the switch to be mounted directly on any vibrating or moving equipment.	 ACCORDION BELLOWS because they make the pressure switch sensitive to vibration.

To get complete specifications and operating data ask for bulletin 402.

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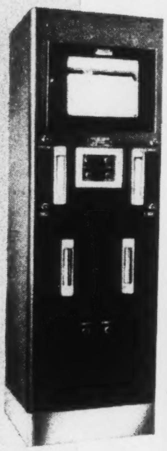

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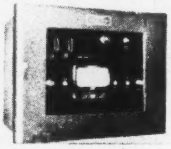

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THIS

VAST IMPROVEMENT OVER CONVENTIONAL HEIGHT GAGES OFFERS A NEW CONCEPT IN THE MAKING OF ACCURATE MEASUREMENTS

The radically NEW OPTIC VERNIER HEIGHT GAGE

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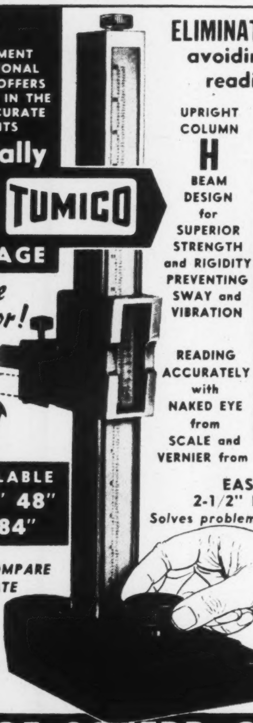

RAPID QUICK ADJUSTMENT
Scriber clamp permits firm clamping above and below jaw

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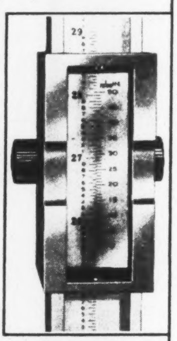

READING ACCURATELY with NAKED EYE from SCALE and VERNIER from REAR of GAGE

EASY READING 2-1/2" LONG VERNIER
Solves problems of reading fractions of 1/1000" quickly and accurately

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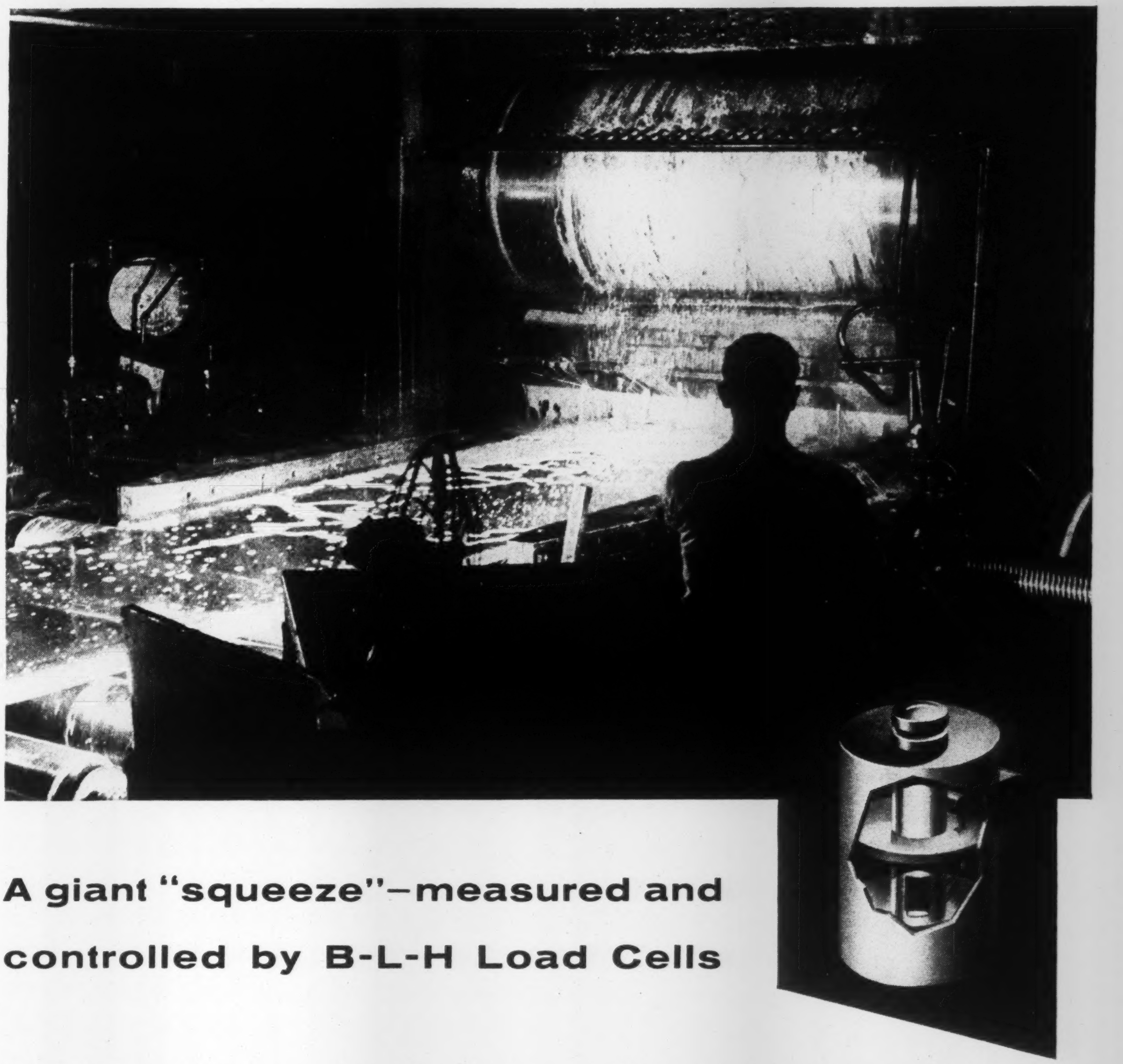

A giant "squeeze"–measured and controlled by B-L-H Load Cells

Despite the tremendous forces unleashed in a rolling mill operation, the actual pressure exerted by the giant rollers can be measured with high precision by built-in B-L-H SR-4® Load Cells. These electronic transducers give the operator exact load readings, enabling him to roll sheets to just the proper thickness every time.

B-L-H transducers will measure any forces involving tension, compression, torque, etc. With appropriate instrumentation, they can also determine center of gravity, weigh loads at rest or in motion, control batch and continuous processes, and record all data required. Long-term accuracy is within ±1/10%, repeatability within ±1/20%. The type and number of applications are virtually unlimited.

SR-4® Load Cells have capacities ranging from 50 to 200,000 lb. Loads on the cells are converted to proportional voltage—permit the instruments for reading or recording changes to be located at any remote point.

For more information on these precision load cells, have us send one of our field men around to see you, without obligation. And write to Dept. 7-D for a copy of Bulletin 4302.

BALDWIN · LIMA · HAMILTON
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new instruments

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process analyzers, monitors, controllers

EXPERIMENTING CONTROL SYSTEM

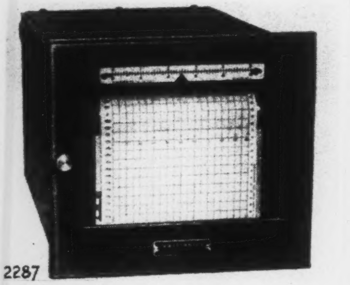
New Automex (Automatic Experimenter) is a new kind of master controller which coordinates the set points of a number of controllers so as to optimize the yield of a process, just as an experienced human operator does. It can be used either to maximize throughput or to minimize cost. In any case, it optimizes the specific product property of most interest to a manufacturer. It can optimize processes in which the relation between input and output measurables is not exactly known, as when process characteristics are changing with time because of uncontrolled (and often uncontrollable) variables, whose existence makes conventional controllers inadequate and renders the complete investigation of a process prohibitively expensive. Illustration shows one demonstration model; production models will probably take several different forms.—*New Products Engineering Dep't, Westinghouse Electric Corp., Box 2278, Pittsburgh, Pa.*.

2286

For more information circle **201** on inquiry card.

RECORDING POTENTIOMETER

New 5" strip-chart potentiometer recorder features plug-in range resistors; is available with various bulb and linear millivolt spans. Wide choice of chart speeds from 1" per hour to 2" per second. Optional features include quick-change chart drive, retransmitting slidewire, event-marking pens and limit switches.—*Westronics Inc., 3605 McCart St., Fort Worth, Texas.*


2287

For more information circle **202** on inquiry card.

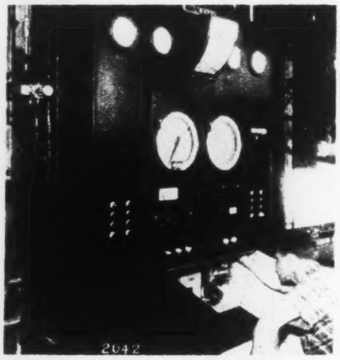
RECORDER FOR LACT UNITS

New Combination BS&W Recorder and Temperature Recorder, with both recording mechanisms in one case, simplifies many pipe-line installations where separate temperature and BS&W recorders would ordinarily be installed. BS&W is recorded by one pen; temperature by a second pen, to provide simultaneous indication of both variables.—*Instruments, Inc., P. O. Box 556, Tulsa, Oklahoma.*

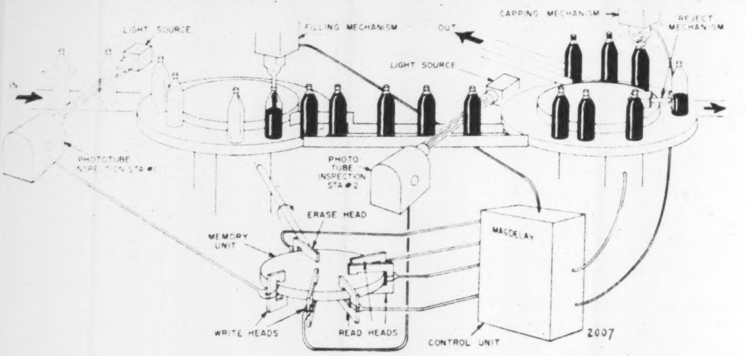
For more information circle **203** on inquiry card.

COMBUSTION CONTROLLERS

Ten new standardized "packaged" electric control systems for varying boiler requirements comprise a completely piped and wired free-standing panel for fully automatic opera-


2042

AUTOMATIZED PRODUCTION LINE INSPECTION AND CORRECTION



2007

New Model 1001 Magdelay system makes automatized process lines produce maximum yields because corrective action, necessitated by missing or defective material sections, is accomplished without stopping the line for manual intervention. It allows for transit times between points of inspection and correction or part removal. Performance is not affected when starting, stopping, jogging, speeding or slowing process line.—*Automation Inc., 212 Worcester St., Wellesley Hills 82, Mass.*

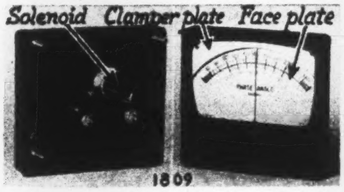
For more information circle **204** on inquiry card.

tion of single-burner gas- and/or oil-fired boilers. Among exclusive features: manual-automatic control station console (incl. indicating lights and push buttons) 33" from floor as in large central-station control stations; all safety and limiting devices. —*The Hays Corp., Michigan City, Ind.*

For more information circle **205** on inquiry card.

"FROZEN-READING" PANEL INDICATOR

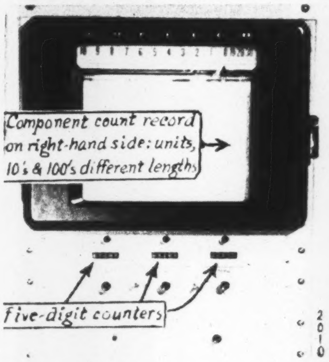
New Memory Meter, believed to be the first of its kind, retains indefinitely a reading taken at any desired instant (not necessarily maximum). Normally, when a reading is desired, rear-mounted solenoid is de-energized; however, solenoid operation can be reversed so that it must be energized to permit free movement of pointer. Size 4½"; almost any dc or ac range. —*Assembly Products, Inc., Chesterland, Ohio.*



For more information circle **206** on inquiry card.

ELECTRONIC INTEGRATOR

New Electronic Integrator featuring fast counting rate (up to 2400 per minute) was developed for use in chromatographic applications; is adaptable to other industrial processes where desirable to integrate the measured variable; has been designed for use with Wheelco 8000 Series strip-chart recording potentiometers. —*Barber Colman Co., Wheelco Instruments Div., Rockford, Ill.*

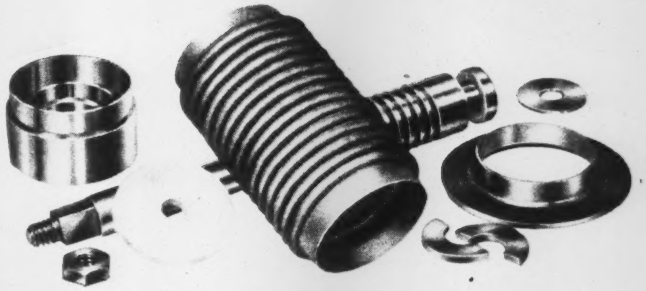

Component count record on right-hand side: units, 10's & 100's different lengths
Five-digit counters
2010

For more information circle **207** on inquiry card.

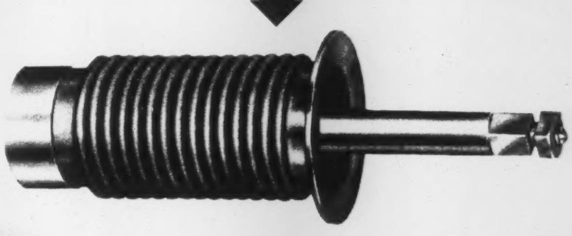
CONTROL MODULES

New Digitrol Building Blocks are modular plug-in components consisting of analog, digital or servomech-

SAVE 6 WAYS



. . . buy complete bellows assemblies from one source!



Why buy bellows members and accessories from several sources . . . and assemble them at still another point? Fulton Sylphon can save you time, trouble and money by *custom* designing, producing and assembling complete bellows assemblies to your specific and exact requirements.

Specialized assembly skill and equipment carefully integrate the bellows and all needed accessories—heads, flanges, brackets, auxiliary bellows, tubing, thermostatic systems and housings. Large selection of bellows sizes, types and metals. The complete assembly is delivered ready to use . . . with these advantages:

1 One source delivery . . . and on time!
2 Entire assembly is pilot tested!
3 Only one incoming inspection!
4 Less handling and paper work!
5 Single source responsibility!
6 Integrated engineering!

Write for Bellows Catalog No. CL-1400

Robertshaw-Fulton
CONTROLS COMPANY

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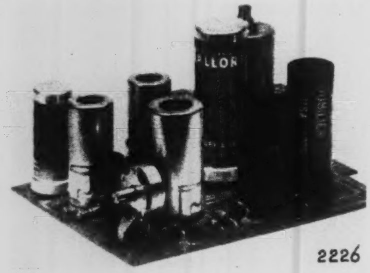
For more information circle **53** on inquiry card.

anism devices. They enable users (1) to assemble complete control systems by selecting prefabricated plug-in modules; (2) to combine analog



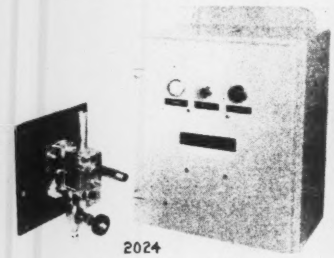
2226

and digital techniques in one control system; (3) to concentrate engineering talent where it belongs; (4) to simplify maintenance problems.—*Electro Precision Corp., Box 669, Arkadelphia, Ark.*

For more information circle **208** on inquiry card.

LIQUID LEAK DETECTOR

New Liquid Leak Detector, for supplemental use with existing combustible gas or vapor detection systems, can be employed for leak control of any organic or inorganic liquid. Units are available for either continuous single-area monitoring, or multi-point scanning. Circuitry is Fail-Safe.—*Davis Emergency Equipment Co., Inc., 47 Halleck St., Newark 4, N. J.*

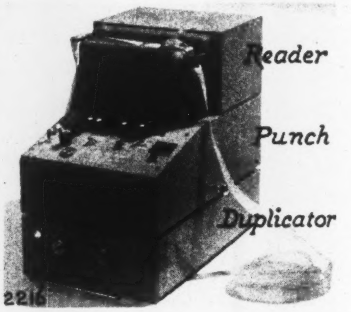


2024

For more information circle **209** on inquiry card.

TAPE PUNCH AND TAPE DUPLICATOR

New Tape Punch and new Tape Duplicator speed processing of data punched in standard 1" tapes. Both units augment Tape Reader (a device that presents 80 bits of information at each advance of tape by simultaneously reading 10 transverse rows of 8 holes each). Using 0.1" hole spacing, any unit can be adapted to existing equipment. Tape Punch allows operator to set up an entire eight-hole line on push buttons which illuminate when pressed. Tape Duplicator punches at over 900 lines per minute.—*California Technical Industries Div. Textron Inc., 1476 Old Country Rd., Belmont, Calif.*



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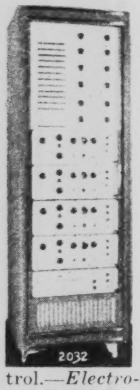
For more information circle **213** on inquiry card.

computing and data processing

PULSE CODE GENERATORS

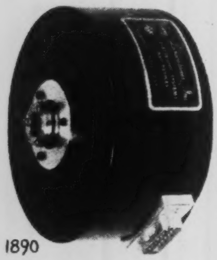


2032

New Series 5100A, for study and test of memory components and digital logic, provide high-speed pulse programs at high impedance and high power output. Single- and multiple-channel 10-bit pulse codes are provided at clock rates to 1 Mc with controllable repeat of selected intervals. Output from each channel is variable from 50 ma to 5 amp peak current, with rise and fall time control.—*Electro-Pulse, Co., 11861 Teale St., Culver City, Calif.*

For more information circle **210** on inquiry card.

SHAFT POSITION ENCODERS

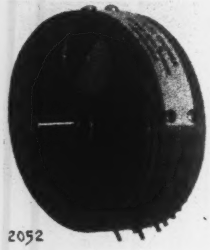


1890

New Series 31 systems convert position into digital form; are readily fitted to many leading types of instruments; feature a glass-fiber insulation disc with segmented conducting tracks and a set of pick-up brushes. Encoder disc is mounted on a hollow shaft which can be slipped on and coupled rigidly to instrument shaft.—*Wang Laboratories, Inc., 37 Hurley St., Cambridge 41, Mass.*

For more information circle **211** on inquiry card.

SHAFT POSITION ENCODERS



2052

New 700 Series encoders are small lightweight units with up to 1024 positions in one revolution of input shaft, obviating need for using precision gearing and reducing driving requirements. ★ New C-711 Series encoders are available with discs coded in Gray code (reflected binary) or a cyclic binary coded decimal. Accuracy is better than one bit and transition points of each bit are held to within 0.05°. Torque <0.4 oz-in and inertia <150 gm-cm^2.—*G. M. Giannini & Co., Inc., 1307 S. Myrtle Ave., Monrovia, Calif.*

For more information circle **212** on inquiry card.

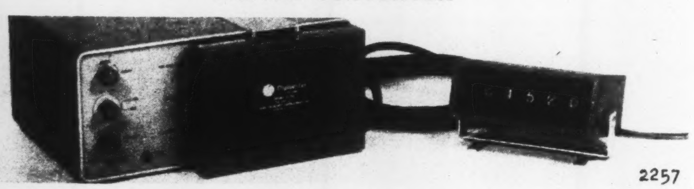
PLUG-IN COMPONENTS

New Comp-Plug PR-5 packages, for use with new AMP Shielded Patch Cord Programming System, include diodes, *RC* networks, etc.; can be used to patch up entire program. Each measures about 5" long; one end terminated in an AMP male pin; other end a solder terminal, a female receptacle, or a cable.—*Eastern Precision Resistor Corp., 675 Barbey St., Brooklyn 7, N. Y.*

1829

For more information circle **214** on inquiry card.

DIGITAL CONVERTER



2257

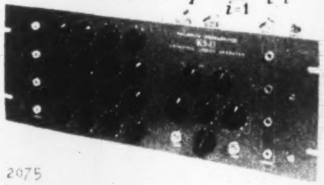
New Model 1520 Digiverter photoelectronic system translates vertical decimal display directly to in-line display; is easily attached to front of decade counter. Models have been developed for all of vertical-decade popular counters and are available with either integral or remote (illus.) in-line Nixie readout. Multi-readouts, relay rack panel, and custom readouts available on special order.—*Radio Frequency Laboratories, Inc., Powerville Rd., Boonton (Twp.), N. J.*

For more information circle **215** on inquiry card.

ANALOG COMPUTER COMPONENT

New Model K5-U Universal Linear Operator, building block for general-purpose analog computation, features

$$e = e_0 + 10^m p^{-n} \sum_{i=1}^{4} a_i e_i$$

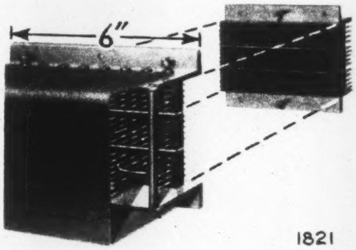

2075

precise parameter programming and a variety of operations in a single chopper-stabilized unit. In aggregations it offers extraordinary versatility and economy. Example: a computer comprising ten K5-U's can quickly and accurately solve 10th-order linear differential equations. Its function may be expressed by the equation lettered on the illustration.—*George A. Philbrick Researches, Inc.*, 230 *Congress St., Boston, Mass.*

For more information circle **216** on inquiry card.

PROGRAMMING PLUG SET

New Model PR-240 provides 240 readily-accessible pins tapered to accept taper-lug jumper wires; features



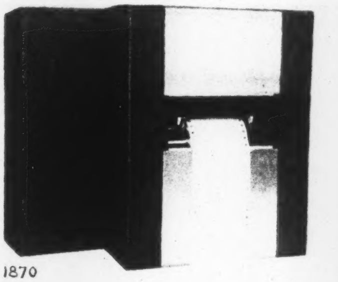
1821

alignment guide pins, provisions for panel mounting receptacle, and quick-off-and-on protective cover.—*Coleman Engineering Co., Inc.*, 6040 *W. Jefferson Blvd., Los Angeles* 16, *Calif.*

For more information circle **217** on inquiry card.

DIGITAL PRINTER

New Model 3260 very-high-speed versatile alphanumeric digital printer features completely transistorized


1870

MODEL 860
FREQUENCY TIME COUNTER
Potter
13200

New!

For any conceivable counting job! A new, low power, light weight, all transistor, 150 KC frequency time counter

Features maximum reliability, long life and small size. Direct Digital in-line readout, does not require matrix. Variable time base permits direct reading of results without consideration of transducer conversion factors.

SPECIFICATIONS

Input Frequency Range
0 to 150 kc

Input Sensitivity
0.1 volt rms, with input attenuation in decade steps

Accuracy
±1 cycle of measured frequency

Crystal Stability
1 cycle/megacycle frequency

Registration
5 digits

Display Time
Continuously variable up to 5 seconds on automatic, until reset on manual

Gate Intervals
Selection of gate duration from 10 microseconds to 10 seconds is available in 10 microsecond increments

Display
In-line, 5 digit readout

Reset
Manual or automatic recycling

Preset Interval Range
10 microseconds to 10 seconds

Accuracy as Interval Generator
±10 microseconds

Recycling Time
10 microseconds maximum

Output
Independent or simultaneous outputs, 10 volts positive, 500 ohms output impedance

Dimensions
8" wide x 12" high x 15" deep

Weight
20 pounds

Output Connections
Rear Panel Jacks

Priced
Competitively with the best vacuum tube counters

At last you can have a high quality, low-power, lightweight, transistorized 150 kc Frequency Time Counter that combines the precision of a laboratory instrument with the ruggedness required for factory applications and will last indefinitely.

The new Potter Model 860, Frequency Time Counter, is a small compact instrument. It may be used to perform normal counting functions and as a timing and frequency measuring device.

In addition, the Model 860 may be used as a preset interval generator to provide preset intervals, delays or counts saving the cost of an additional instrument when preset interval generating functions are required.

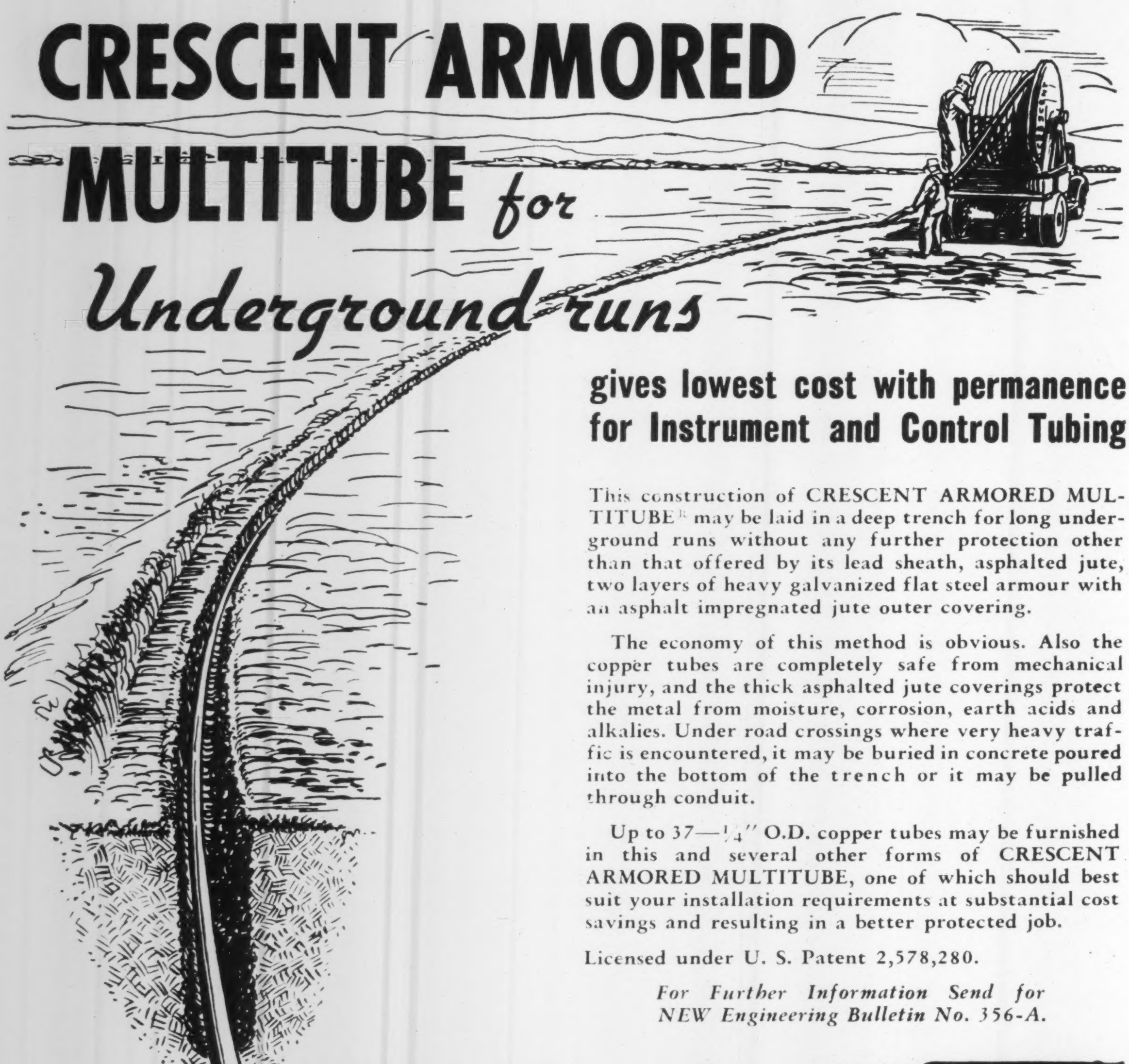
Timing and frequency features of the Model 860 include direct measurement of frequency from 0 to 150 kc, frequency ratio determination, period measurements for 1 or 10 cycles, and time interval measurements for intervals from inputs up to 150 kc. Predetermined counting to any number up to 9999 with extension in steps of 10 or 100 to 999900 and external count gating are additional features.

Call or write the factory or your Potter Instrument Company representative for further information or for assistance with your counting problems.

POTTER INSTRUMENT COMPANY, Inc.
Sunnyside Boulevard, Plainview, New York
OVerbrook 1-3200

For more information circle **54** on inquiry card.

CRESCENT ARMORED MULTITUBE *for* *Underground runs*



gives lowest cost with permanence for Instrument and Control Tubing

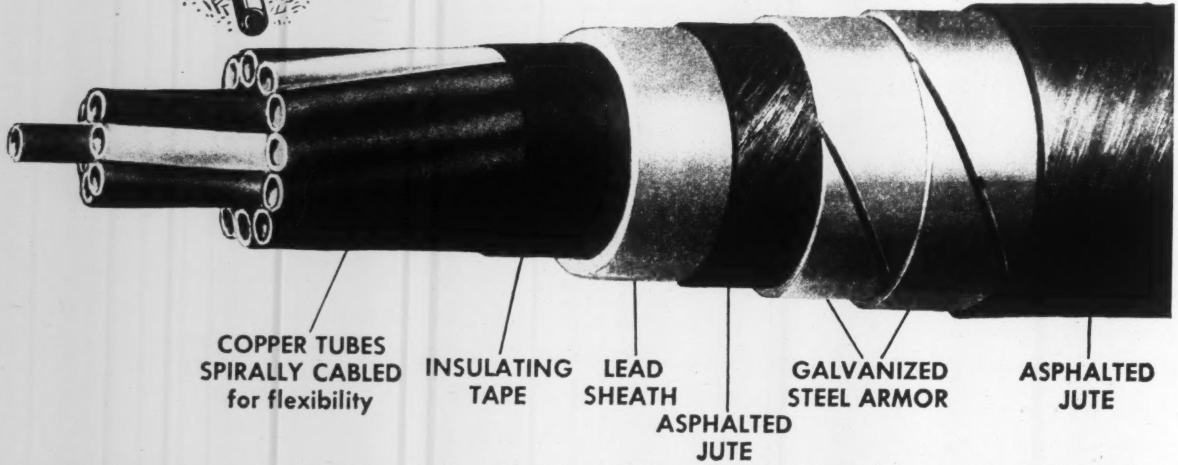
This construction of CRESCENT ARMORED MULTITUBE[R] may be laid in a deep trench for long underground runs without any further protection other than that offered by its lead sheath, asphalted jute, two layers of heavy galvanized flat steel armour with an asphalt impregnated jute outer covering.

The economy of this method is obvious. Also the copper tubes are completely safe from mechanical injury, and the thick asphalted jute coverings protect the metal from moisture, corrosion, earth acids and alkalies. Under road crossings where very heavy traffic is encountered, it may be buried in concrete poured into the bottom of the trench or it may be pulled through conduit.

Up to 37—¼″ O.D. copper tubes may be furnished in this and several other forms of CRESCENT ARMORED MULTITUBE, one of which should best suit your installation requirements at substantial cost savings and resulting in a better protected job.

Licensed under U. S. Patent 2,578,280.

For Further Information Send for NEW Engineering Bulletin No. 356-A.



CRESCENT INSULATED WIRE AND CABLE CO.
TRENTON, NEW JERSEY

For more information circle 55 on inquiry card.

circuit modules; can print more than 400 digits or characters per second; can be connected to most data-producing sources with little modification; can be supplied with up to 40 columns of numeric or alphanumeric characters; can print up to 20 lines per second for alphanumerical applications, normally on multiple-copy fanfold paper.—*Potter Instrument Co., Sunnyside Blvd., Plainview, L.I., N.Y.*

For more information circle **218** on inquiry card.

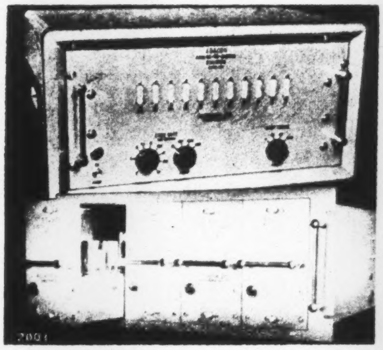
FREQUENCY CONVERTER

New Type 2 frequency-to-analog converter for use in telemetering, computer and other electronic data-handling systems, features 0.1% linearity; is completely electronic (no mechanical choppers) and uses silicon zener diodes to assure 0.1% stability. Transient response 1 ms; range of standard converter 100 to 5000 cps (others available on request). Output 0 to 1 ma per 1000 cps of input continuously variable with built-in span adjustment. Dimensions 5 x $3\frac{1}{2}$ x $12\frac{1}{4}$"; weight $8\frac{3}{4}$ lb.—*Cox Instruments Div., George L. Nankervis Co.,* 15300 *Fullerton Ave., Detroit* 27, *Mich.*

For more information circle **219** on inquiry card.

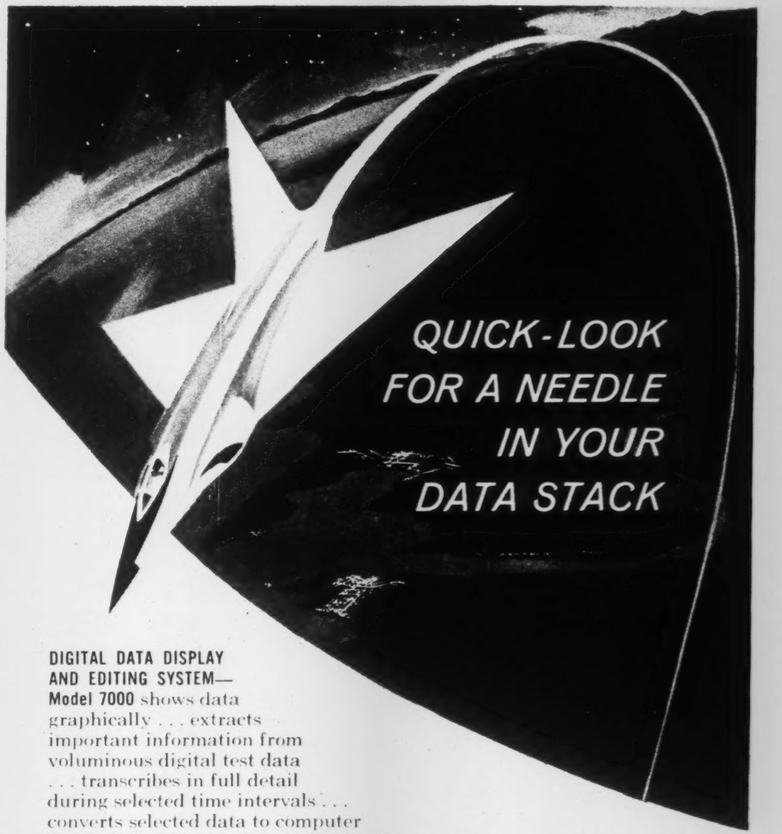
ENCODERS AND DECODERS

New Model 2KB Edacon encoder is capable of analog-to-digital conversion of up to 2,000 codes per second.

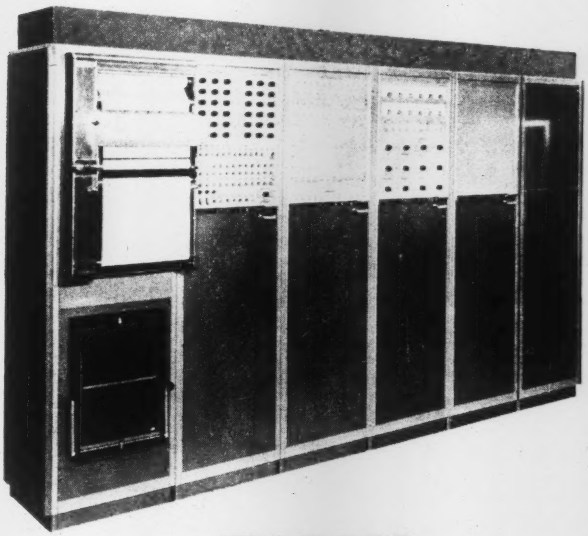


Code is binary having 10 bits plus sign; code accuracy 1 part in 2048; maximum bit rate 22,000 per second. Built-in power supplies include reference voltage source of 0.005% stability. ★ New Model 10B Edacon decoders are capable of digital-to-analog conversion of up to 200,000 parallel 10-bit binary codes per second. Code accuracy 0.05%. Built-in power supplies feature drift of less than 0.001% of full range. Analog output range is ±50 v @ at 25 ma. ★ Model 10BR Decoder with reference voltage source of 0.005% stability can supply reference current to three other Model 10B Decoders.—*Andromeda, Inc.,* 3742 *Howard Ave., Kensington, Md.*

For more information circle **220** on inquiry card.



DIGITAL DATA DISPLAY AND EDITING SYSTEM— Model 7000 shows data graphically . . . extracts important information from voluminous digital test data . . . transcribes in full detail during selected time intervals . . . converts selected data to computer format. Visual and transcription features operate simultaneously or independently . . . start and stop anywhere. Now reducing man and computer hours for The Martin Company. This is but one of a number of Tally systems now demonstrating an ability to analyze and solve special data processing problems—scientific or commercial. Write for details—or Tally's facility brochure.



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REGISTER CORPORATION Department 100, 5300 14th N.W., Seattle
For more information circle **56** on inquiry card.

Double-barrel solution to all wiring problems!

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WIRES & CABLES

QUALITY *plus*— SERVICE

Longer lasting CHESTER Plasticord-Plasticote wires, and nylon and teflon* insulated conductors, are available in standard or custom constructions for every requirement. All are service-proven for complete reliability for the specific application for which they are engineered. And equally reliable, is the service behind them...from "crash" deliveries to engineering assistance on the design of special purpose constructions!

"Chesty" says: FOR EASIER INSTALLATION AND LONGER LASTING DEPENDABILITY, WIRE IT WITH CHESTER!

—for Smooth Pliability with Super-Durability

"Airsac" TV Lead-in Wire
Appliance Wire
Annunciator Wire
Annunciator Cable
Antenna Loop Wire
Braided Wire
Coaxial Cable
Custom Cable Constructions
Flame Retardant High Voltage Wire
Flexible Bell Cordage
High Frequency Test Lead
High Frequency Lead Wire
Intercom, Control and Audio Cable
Microphone Cable
MIL Hook-up Wire
Miniature Wire and Cable
Multiple Conductor Cable
Nylon Coated Wire
Overbraids
"Parallead" TV Lead-in Wires
Phonograph Pick-up Cable
Photoelectric Cell Cable
Rotor Cable
RVC-300 Apparatus Wire
Shielded Cable
Teflon Lead Wire
Telephone Bridle Wire
Telephone Cable
Telephone Inside Wire

*DuPont Tradename

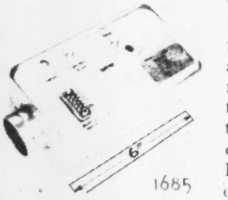
CHESTER CABLE CORP.
A Subsidiary of Miami Copper Company
5 HILL STREET, CHESTER, NEW YORK, U.S.A.
PIONEER PRODUCERS OF PLASTIC INSULATED WIRES AND CABLES

For more information circle 57 on inquiry card.

telemetering

RF AMPLIFIER

New Model 1466, said to be the smallest and most rugged 100-watt telemetering amplifier, features 2-watt drive and 215-260-Mc range; operates under all missile vibration, acceleration and heat conditions. Built-in blower allows operation up to 125°C.—*Telechrome Mfg. Corp., 28 Ranick Drive, Amityville, N. Y.*

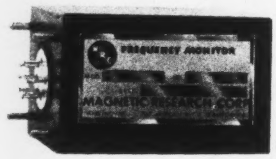


1685

For more information circle 221 on inquiry card.

FREQUENCY MONITORS

New magnetic Frequency Discriminators convert frequency deviation into analog voltage variation for telemetering, etc.; produce a well-filtered 0-5-vdc output voltage in response to a frequency deviation; are available for power sources operating at frequencies up to 10 kc. Linearity of frequency-to-voltage conversion is better than 0.5% for standard models. —*Magnetic Research Corp., 3160 W. El Segundo Blvd., Hawthorne, Calif.*

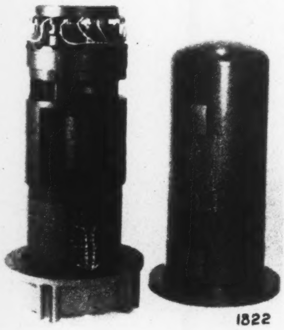


1855

For more information circle 222 on inquiry card.

PDM MULTIPLEXER

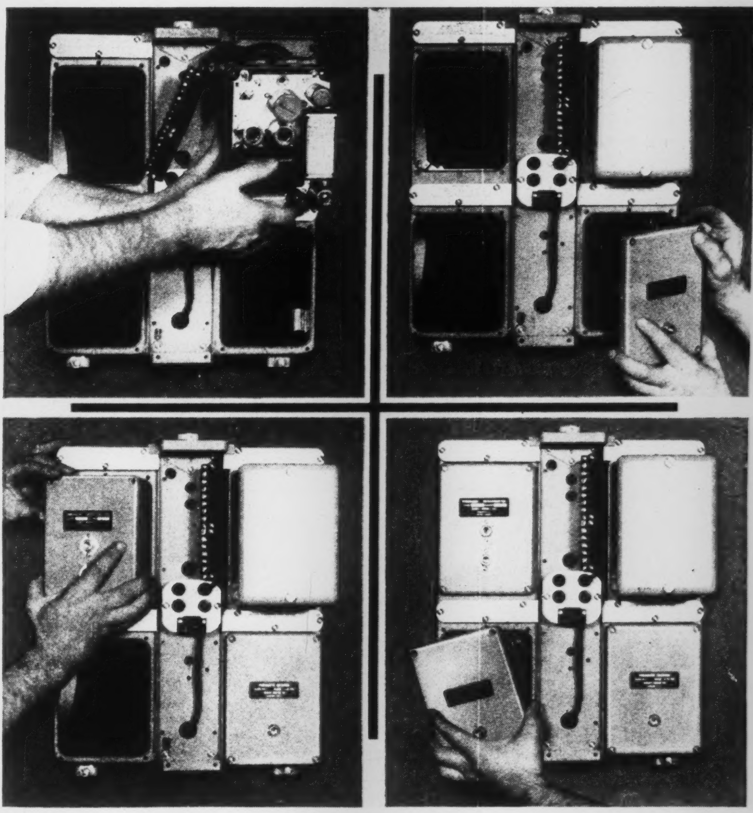
New Type 40-101 Plexicoder commutates signals from up to 90 pickups at 112.5 samples per second and converts them into duration-modulated pulses for telemetering or magnetic tape recording; is designed for flight test instrumentation, test stands, data handling systems, etc.—*Consolidated Electrodynamics Corp., Pasadena, Calif.*



1822

For more information circle 223 on inquiry card.

CUSTOM BUILD your own Bailey Recorder



These four views of the back of a Bailey Recorder show how four plug-in units may be added as needed to meet almost any recorder application.

The freedom and flexibility of "do-it-yourself" instrumentation is yours in the Bailey Recorder. A variety of plug-in units make it possible to record, control, and retransmit any variable that can be converted to a pneumatic or electric signal.

The basic plug-in units are the Bailey a-c and d-c Electronic Receivers and Pneumatic Receivers. Any four of these may be used in one recorder, intermixed in any way, to provide four continuous records on one chart.

For automatic control, other plug-in units are available.

For square root extraction or linear integration, there are two plug-in variations of the Bailey Integrator.

When you want a pneumatic signal that varies according to a pre-set pattern plug in a Bailey Program Controller.

Periodic running time of a condition or process is recorded on the chart when a Bailey Running Time Recorder is used.

These and other plug-in units are described in Product Specification E12-5. Some companies stock Bailey Recorder cases and assorted plug-in units. As instrumentation and control needs arise they build up the kind of recorder-controller required, using the proper plug-in units from stock. Unmatched versatility such as this means lower instrumentation costs.

For the complete story of how easily you can custom build this recorder to your needs, see your Bailey Engineer.

G43-1

BAILEY METERS

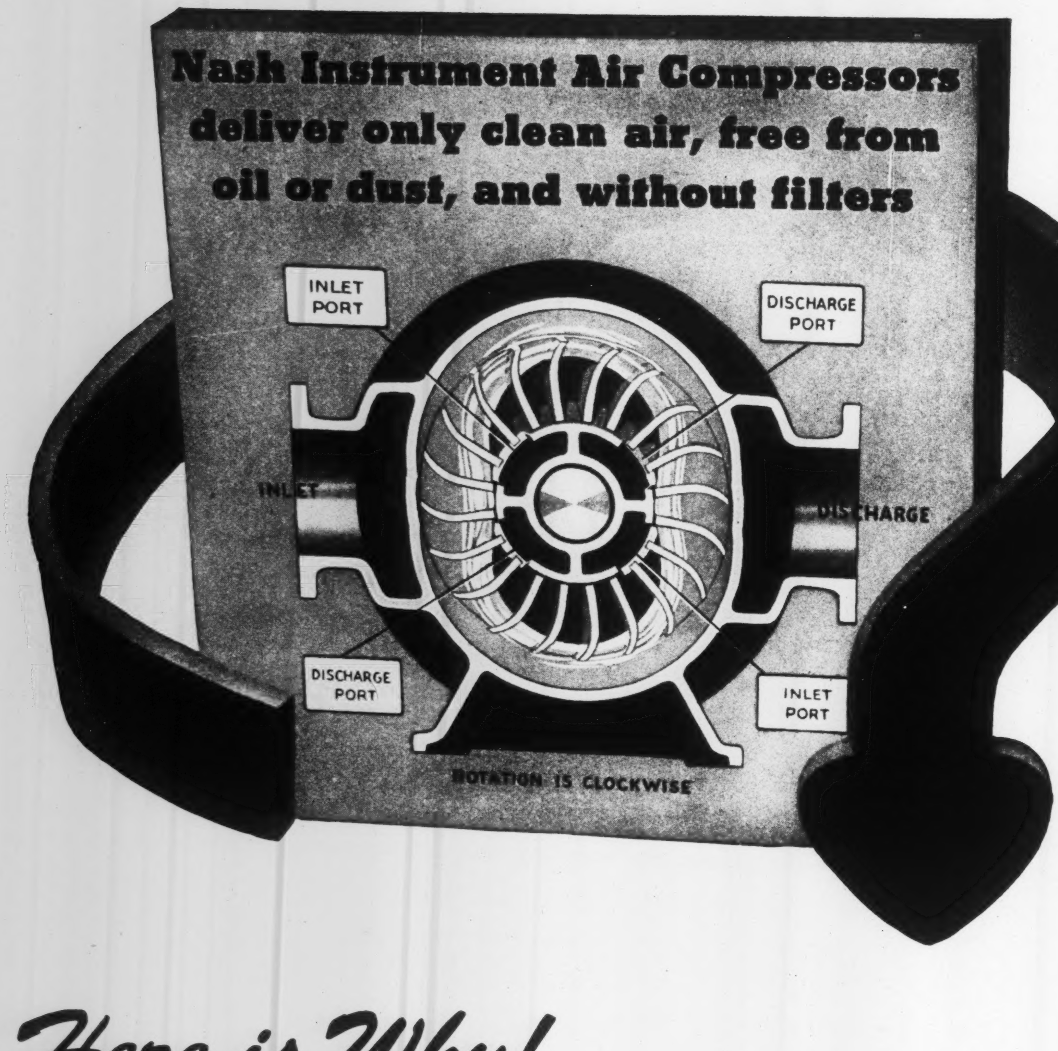
Instruments and controls for power and process

BAILEY METER COMPANY

1041 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

For more information circle **58** on inquiry card.


Nash Instrument Air Compressors deliver only clean air, free from oil or dust, and without filters
INLET PORT
DISCHARGE PORT
INLET
DISCHARGE
DISCHARGE PORT
INLET PORT
ROTATION IS CLOCKWISE

Here is Why!

You can dispense with oil filters and dust filters when you install ®Nash® Clean Air Compressors. You can save the cost of maintaining these devices. You can greatly reduce instrument maintenance costs. For the Nash employs no internal lubrication, therefore no troublesome oil is in the delivered air. Moreover, air from a Nash is thoroughly washed and cooled as it passes thru the pump. Dust in the plant atmosphere, even fly ash, is immediately removed.

®Nash® Clean Air Compressors are simple, with only one moving element. No valves, gears, pistons, sliding vanes, or other enemies of long life and constant performance complicate a Nash. No aftercoolers are needed. You will find it profitable to investigate these pumps, now.

No oil filters.
No dust filters.
No internal lubrication to contaminate air handled.
No internal wearing parts.
No valves, pistons, or vanes.
Non-pulsating pressure.
Original performance constant over a long pump life.
Low maintenance cost.

NASH ENGINEERING COMPANY
370 WILSON, SO. NORWALK, CONN.

photoelectric equipment

PHOTOTRANSISTOR

New Type 2N469 *p-n-p* phototransistor is a highly improved version of Type 2N318: smaller and with greater optical sensitivity, high gain and low leakage current (especially important in punched-card and tape readouts). It is extremely resistant to shock and vibration and is capable of exceptionally long service-life under severest conditions.—*General Transistor Corp.*, 130-11 90*th Ave., Richmond Hill* 18, *N. Y.*

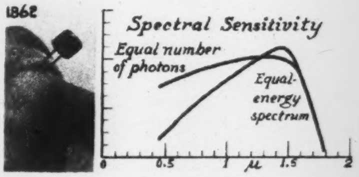
2037

For more information circle **224** on inquiry card.

INTEGRAL-LENS PHOTODIODE

New hermetically-sealed germanium photodiode features a narrow integral lens which concentrates light on 1 mm² sensitive portion of junction area.—*Nucleonic Products Co., Inc.*, 1601 *Grande Vista Ave., Los Angeles* 23, *Calif.*

1862



For more information circle **226** on inquiry card.

PHOTOMULTIPLIER SUPPLY

New Model PS 128 was designed specifically to be used with photomultiplier phototubes as a direct replacement for a battery pack. Input 95-125 vac; output 500-1100 vdc continuously variable; regulation 0.04% or less over input range; ripple 0.01% or less; dimensions 13x8x8½"; weight 18½ lb.—*Axler Associates, Inc.*, 102-42 43*rd Ave., Corona* 68, *N. Y.*

For more information circle **225** on inquiry card.

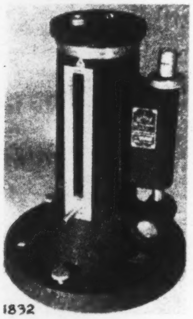
PHOTOCELL AMPLIFIER

New Model LS 242, designed for use with conventional barrier-layer cells, amplifies an optically-chopped signal and feeds this signal to a high-impedance indicator or to a low-impedance recorder whichever is preferred. As much as 60 db signal-to-noise ratios can be obtained with narrow-band optical transmission filters.—*Axler Associates, Inc.*, 102-42 43*rd Ave., Corona* 68, *N. Y.*

For more information circle **227** on inquiry card.

pressure and vacuum

HIGH-PRECISION MANOMETER

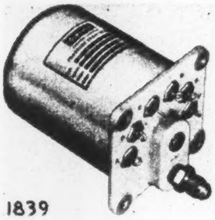


1832

New Askania Minimeter features accuracy of 0.01 mm (0.0004") water gage; can be used also for vacuum and d p measurements; is especially suitable for calibrating other low-pressure instruments. Built-in optical system for quick determination. Range 150 mm (about 6").—*EPIC, Inc.*, 154 *Nassau St., New York* 38, *N. Y.*

For more information circle **228** on inquiry card.

PRESSURE PICKUP



1839

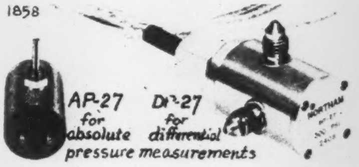
New Model 451212 features 2000-wire (0.05%) resolution, and precise static and dynamic balancing of unique mechanism, whence combined linearity, hysteresis, and repeatability error of 1% of reading, or less. Available in ranges from 0-10 through 0-50 psia, psid or psig.—*G. M. Giannini & Co., Inc.*, 918 *E. Green St., Pasadena* 1, *Calif.*

For more information circle **229** on inquiry card.

PRESSURE PICKUPS

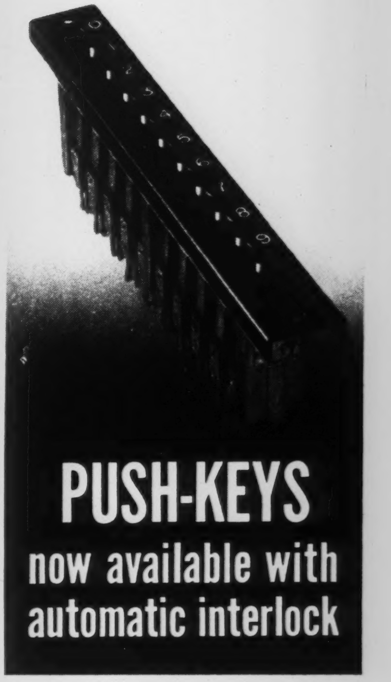
New variable-reluctance pressure pickups, now commercially available, have proved their reliability in missiles "under shock, vibration and acceleration where other transducers fail"; can be operated with ac carrier sytems from 400 to 20,000 cps. Coil inductances can be specified for compatibility with desired carrier system. (Since pickup's frequency exceeds 2500 cps, best results are obtained when using recently-developed Northam 3000-cps carrier system.) Many ranges to choose from.—*Northam Electronics, Inc.*, 2420 *N. Lake Ave., Altadena, Calif.*

1858



For more information circle **230** on inquiry card.

STROMBERG-CARLSON



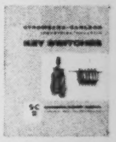
In such precision operations as automation programming, you can now eliminate the risk of pushing more than a single button at a time.

This new interlock feature is based on a simple arrangement of sliding cams. Only one button at a time can be depressed. This feature is available in all multiple-pushbutton assemblies (7, 10, 12 and 20 button arrangements).

All "telephone-quality" advantages of Stromberg-Carlson keys continue as before. You may apply "make," "break," "break-make" and "make-before-break" combinations as required. You get standard spring combinations with Form A, C or D contacts—or you may order special strips of keys with intermixed contacts.

Buttons are available in white or colors—blank or with letter or number designations.

For complete technical data on Stromberg-Carlson Key Switches send for our illustrated Bulletin T-5002R.



STROMBERG-CARLSON

A DIVISION OF GENERAL DYNAMICS CORPORATION

Telecommunication Industrial Sales
113 Carlson Road, Rochester 3, N. Y.

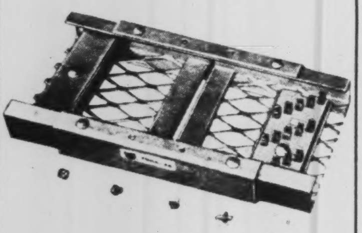
Electronic and communication products for home, industry and defense

For more information circle **59** on inquiry card.

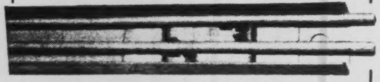
SPECIFY

P.W

for Supporting Instrument Tubing



P-W Manufactures a complete trough system with channel connectors. Drive rivets are used for quick assembly.—Extension Connectors eliminate field cutting—Adjustable connectors for any change in direction or elevation—I Section for long spans—Tube Clips—Cushion Clamps



Raceway to support a limited number of tubes with connectors, elbows, tees, etc.—Bulkhead Bar. P-W systems are available in widths from 1" to 24" and in lengths from 1' to 16'.

Twist-Rack

The Structure To Support Tubetrof . . . Cabletrof . . . Shelving . . . Conduit . . . Cables . . . Pipe, Etc.

Write today for Bulletin 656-G

P-W INDUSTRIES, INC.
Duncan & Melrose Sts.,
Philadelphia 24, Pa.

(Representatives to serve you!)

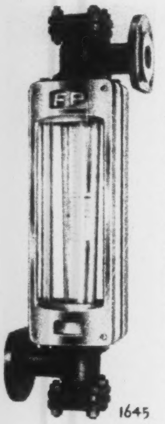
For more information circle 60 on inquiry card.

flow-rate, level

MAGNETIC FLOWMETER

New ½" magnetic flowmeter measures flow rates as low as 3 gpm; is particularly useful where small flows are ratioed to larger ones; offers full advantages of the larger instruments (1" and up): performance unaffected by pressure, viscosity, density or changes in conductivity of flowing liquid.—*The Foxboro Co., Foxboro, Mass.*

For more information circle **231** on inquiry card.



1645

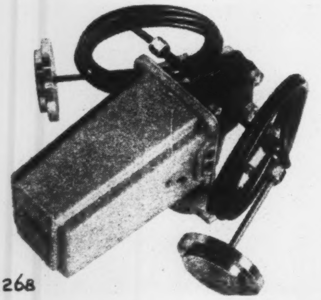
ANTI-CORROSION FLOWMETER

New variable-area flowmeter with vitreous-enamel-lined cast-iron fittings will not only handle corrosive fluids but will stand temperatures and shocks destructive to meters made of more fragile materials.—*Fischer & Porter Co., 455 Jacksonville Road, Hatboro, Pa.*

For more information circle **232** on inquiry card.

FLOW & LEVEL TRANSMITTER FOR HARD-TO-HANDLE FLUIDS

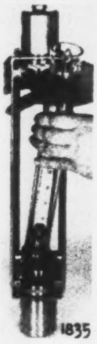
New 205T Volumetric Differential Pressure Transmitter simplifies difficult flow and liquid level measurements: corrosive fluids, liquids that "jell" when not in motion, colloidal suspensions and slurries. It obviates costly special installations and maintenance of winterized lead lines ordinarily required between transmitter and process. Entire sensing system, including both sensing elements, their capillaries, and differential pressure sensing diaphragm to which they connect, is factory-filled with silicone compound and permanently sealed. Mercuryless force-balance system converts d/p measurement to 3-15-psi signal.—*Taylor Instrument Companies, Rochester 1, N. Y.*



2268

For more information circle **233** on inquiry card.

SNAP-IN ROTAMETER



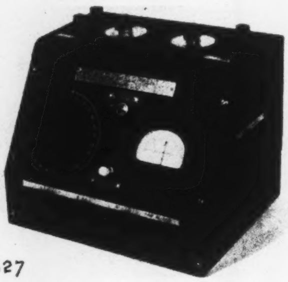
New 2700 Series use O-rings to seal tube ends to metal fittings, eliminating nuts, packing glands and adjustments. Piping strains cannot be transmitted to glass metering tube since tube "floats" in O-rings. Side frames and front and rear covers are also of snap-in construction. Three sizes cover flow ranges from <1 cc/min to 40 gal/min.—*Fischer & Porter Co., 577 Jacksonville Rd., Hatboro, Pa.*

For more information circle **234** on inquiry card.

temperature

THERMOMETRIC BRIDGE

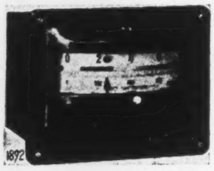
New Model TB101-5 Thermo Bridge is essentially a special-purpose Wheatstone bridge designed to read temperature change by change-in-resistance method. Dial is calibrated in C degrees change from any preset reference, using primary elements having a linear coefficient within limits of intended range.—*Dynamic Development Co., 59 New York Ave., Westbury, L. I., N. Y.*



1827

For more information circle **235** on inquiry card.

ALUMINUM CASE PYROMETERS



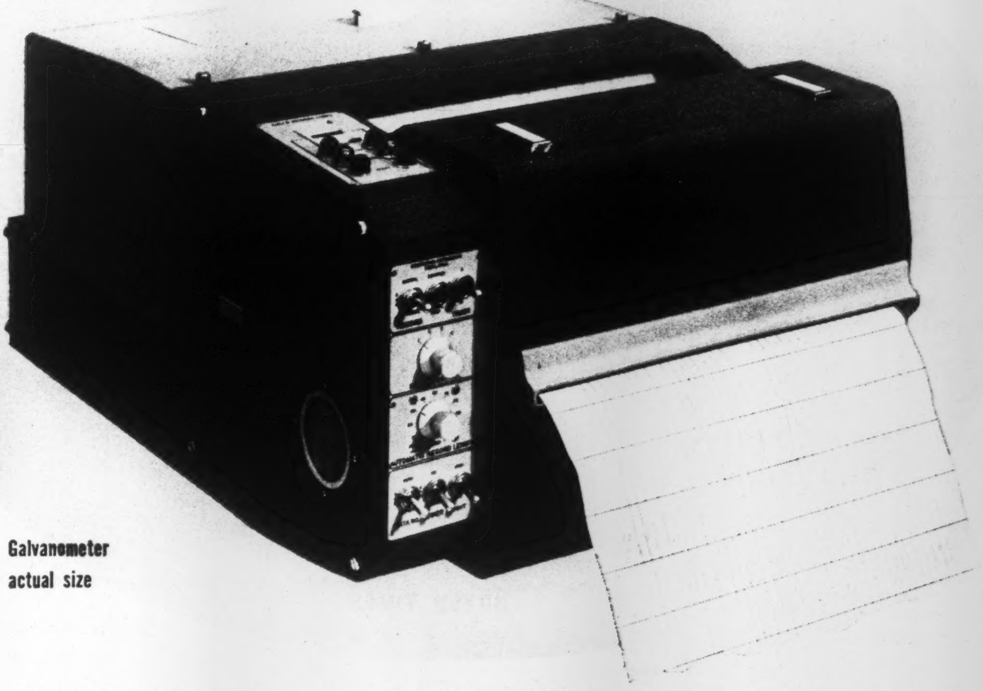
New Gardsman pyrometers feature new diecast aluminum case (unless ordered otherwise) which facilitates some functions. Setting knob now has a guard to preserve precise setting and still permit wiping glass or face. Calibrating spool now is accessible without disassembling instrument. Corner screws now are recessed. Uniform casting to rigid tolerances eliminates variations between instruments. —*West Instrument Corp., 4363 W. Montrose Ave., Chicago 41, Ill.*

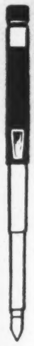
For more information circle **236** on inquiry card.

model 602 Direct Recording

OSCILLOGRAPH

D/R





Galvanometer actual size

DIRECT READOUT • NO POWDERS • NO CHEMICALS

SPECIFICATIONS

MAXIMUM CHANNELS: 50 Channels
RECORD WIDTH: 12 inches
MAGAZINE CAPACITY: 200 feet
RECORD SPEED RANGE: .0865 to 138.5 per second
WRITING SPEED: Above 30,000" per second
OPTICAL ARM: 11 inches
POWER REQUIREMENTS: 115V 60 cps
TIMING LINES: 0.01 with 0.10 second (accentuated intervals)
SIZE: 11 1/16" x 16 13/16" x 24½"
WEIGHT: 130 pounds

Swift readout of the completed records as they flow from the 602 D/R Direct Recorder, places this advanced instrument on the top priority list with test engineers and laboratory researchers who prefer INCREASED ACCURACY + TIME SAVED.

Outstanding features include: full width timing lines — record numbering and identification — wide range of recording speeds — use of standard MI Galvanometers, all exclusive to the MI model 602 Direct Recorder OSCILLOGRAPH.

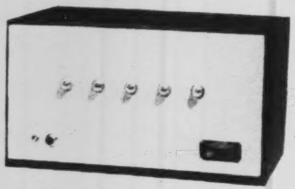
Midwestern Instruments manufactures several models of oscillographs — a model for practically any application.

MIDWESTERN INSTRUMENTS
41ST AND SHERIDAN / TULSA, OKLAHOMA

For more information circle **61** on inquiry card.

Post Decitron
electronic products

Model **MC**

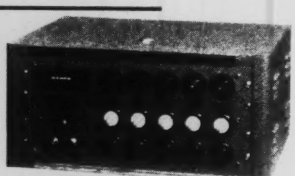


Post's Multi-Channel Input unit . . . accumulates "counts" from several different production lines where total count is desired, utilizes separate photoheads for each line. Anti-coincidence circuit keeps count accurate even if objects on two different lines break beam simultaneously.

Model **SD-IT**

Outmodes all mechanical counters. Capable of operating at speeds up to 100 units per second. Single "count" indicated on the six digit totalizer as each *tenth* item breaks the light beam. Counts dozens or gross with 12 place counting tube.

Model **PW-5**



Preset electronic counter with built in warning system. Available in models for counts of 1-100 (PW-2) to model with range 1-100,000 (PW-5). Will count in batches. Warning device may be used to coordinate secondary circuit just before desired count is reached. Will stop machine, cut, divert or perform any other operation. Automatically resets to zero when preset number is reached.

POST ELECTRONICS
Division of Post Machinery Co.
160 Elliott St., Beverly, Mass.

Decitron
POST ELECTRONICS
Division of Post Machinery Co.
160 Elliott St., Beverly, Mass.

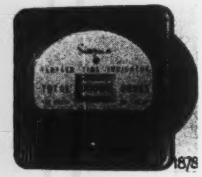
☐ Send literature on Model ________
☐ Please send name of nearest representative

Name ____________________
Company ____________________
Address ____________________
City ____________ State ____________

For more information circle **62** on inquiry card.

time, sequence, speed, counting

HOUR METERS

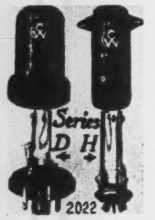


1878

New Elapsed Time Indicators are available in 3½" round (55ET), 3½" round shroud (56ET), and 3½" rectangular (57ET) cases. Self-starting synchronous clock motor; 120 or 240 vac; auto-resetting counters for 0-99999 or 0-9999.9 hours.—*Simpson Electric Co., 5200 W. Kinzie St., Chicago 44, Ill.*

For more information circle **237** on inquiry card.

THERMAL TIME DELAY RELAYS

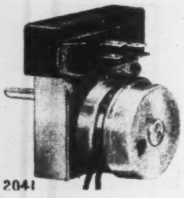


2022

New positive-acting Series D is designed with octal base for time delays from 5 to 90 sec; operates from 0 to 85°C. ★ New Series H, for military applications, operates under 0-500-cps vibration at 10 G and shock up to 50 G, at altitudes to 70,000 ft, temperatures from −65°C to 125°C. ★ Both Series: Sp-st n-o or n-c contacts rated 3 amp 120 vac or 2 amp 32 vdc resistive loads. Heater voltages from 5 to 125 vac or vdc. Standard 6.3, 26.5 or 117 v.—*Curtiss-Wright Corp., Electronics Div., Wood-Ridge, N. J.*

For more information circle **238** on inquiry card.

DRYER TIMER

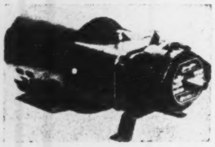


2041

New totally-enclosed Dryer Timer provides appliance manufacturer with an effective means for minimizing rejects and service calls. Terminals are rigidly supported at both ends to prevent misalignment if struck during installation.—*Haydon Div., Gen'l Time Corp., Torrington, Conn.*

For more information circle **239** on inquiry card.

VARIABLE SPEED REDUCER



New motorized Zero-Max Stepless Variable Speed Reducer is available in torque ratings from 20 lb-in through 120 lb-in by addition of reduction gearheads of various ratios.—*Revco, Inc., Minneapolis 5, Minnesota.*

For more information circle **240** on inquiry card.

OVERSPEED PROTECTORS

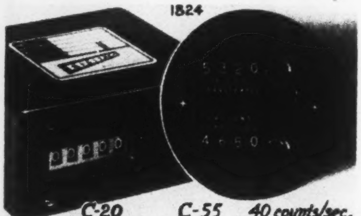
New FD-100 Series Frequency Detectors provide instantaneous cut-off when speed of rotating devices exceeds a preselected value; accept input signals from ac tach generators or magnetic pickup coils but can be used also with turbine flow sensors. Response time within 10 ms through use of transistor switching to control output current. Absence of mechanical contacts assures unlimited life and trouble-free operation under extreme shock and vibration. Detectors operate on 28 vdc and provide a 28-v output signal capable of operating solenoid valves or relays. Accuracy of trip point is within 1%. Dimensions 4½" x 3½" x 2½"; weight 1¾ lb.—*Waugh Engineering Co., 7842 Burnet Ave., Van Nuys, Calif.*

For more information circle **241** on inquiry card.

MULTI-PURPOSE COUNTERS

New line of high-speed electromechanical counters includes undirectional and bidirectional units able to add and subtract impulses and function as summation counters. Only two of the five distinct forms are illustrated. Feature: exclusive dynamically-balanced incremental actuator. Life span exceeds 10,000,000 counts; standard rates from 15 to 40 counts per second (higher on special request).—*Digitac, Inc., 420 S. Beverly Drive, Beverly Hills, Calif.*

1824



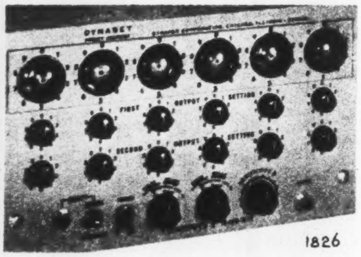
C-20 Bidirectional 15 counts/sec.

C-55 40 counts/sec. Unidirectional: one side add & one subtract

For more information circle **242** on inquiry card.

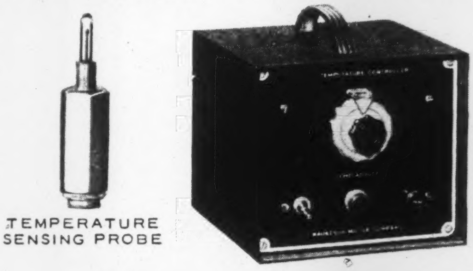
PRESET COUNTER

New Dynaset, said to be "the first transistorized preset counter to be designed," features virtually unlimited life, etched-circuit plug-in construction, only cold-cathode glow counters



1826

For **CLOSE** Temperature Control



WAUKESHA
TEMPERATURE CONTROLLER

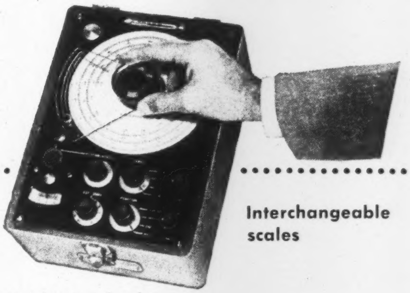
This simple, versatile instrument, developed for ASTM Engine Test Methods for Rating Motor Fuels, is equally well adapted to general laboratory or industrial temperature control applications. Range is approximately 80° F. to 400° F. with the standard sensing pickups. A small thermistor sensing probe and a saturable reactor provide continuously modulated proportional control of the current to the heating element, without moving contacts or relays. It features high sensitivity, close control, and easy adjustment of the control point by coarse and fine co-axial dials. It is housed in the portable cabinet shown, or may be panel mounted. Operates on 110 volts AC to control directly heaters up to 1000 watts, and can be used as a pilot controller for higher load capacity. Write for further information.

Fuel Research Division
WAUKESHA MOTOR COMPANY
WAUKESHA, WISCONSIN

For more information circle **63** on inquiry card.

Calibrate Pyrometers

. . . Measure Temperatures



Read temperatures or millivolts directly

Interchangeable scales

A portable standard

The Pyrotest checks recorders, controllers and thermocouples . . . measures temperatures. It is a precision signal source, simulating thermocouple temperatures, for checking other potentiometers. Built-in "run up" permits checking of millivoltmeters.

19 different stock scales will fit one Pyrotest! Scales interchange in seconds. °F. or °C. calibrations for all types of thermocouples supplied. Scales directly read temperatures or millivolts.

Features include cold junction compensation, high accuracy, built-in standard cell. Request Bulletin 9B for complete specifications.

TECHNIQUE ASSOCIATES INC.
P. O. BOX 91 • INDIANAPOLIS 6, INDIANA

For more information circle **64** on inquiry card.

NEW HAGEN
hand set
time delay relay

controls 1 to 10 circuits in sequence
HAGEN
MINUTES
PRESS TO ADJUST DIAL — STOP
HOLD
HAGEN MANUFACTURING CO. INC.

Foolproof on Repeat Settings

No danger of over-timing when you repeat a process several times — each with the same timing. On the first run, operator simply presses the stop release button and sets the adjustable stop (both shown in blue) at the desired time . . . then turns the pointer as far to the right as it will go . . . it can't go beyond the stop. Thus the setting is always correct — on the first and all subsequent runs.

A synchronous motor returns the cam shaft to "O" position, tripping switches in accordance with time settings. The process is stopped automatically.

A wide selection of snap-action switches is available . . . as well as cam combinations. The Hagen Hand Set Time Delay Relay Model 73 is the answer to controlling solenoid valves in an industrial process, starting a group of motors in sequence, for pump controls, and many other uses.

Send for Bulletin 1510

HAGEN
MANUFACTURING COMPANY, INC.
Moline, Illinois
Subsidiary of Eagle Signal Corporation

HAGEN MANUFACTURING COMPANY, INC.
Dept. IA-458 , Moline, Illinois

Please send Bulletin 1510 on the new Hagen Hand Set Time Delay Relay.

NAME AND TITLE

COMPANY

ADDRESS

CITY ZONE STATE

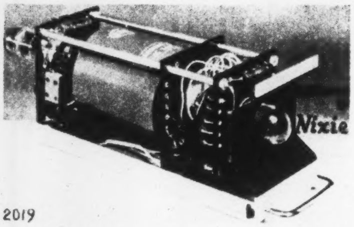
For more information circle **65** on inquiry card.

and transistors—no hot cathode tubes. Count rate 0 to over 5000 per second. Available in single and dual presets, 2 to 6 digits. Option: Nixie in-line readout.—*Dynapar Corp., 5150 Church St., Skokie, Ill.*

For more information circle **243** on inquiry card.

MEGACYCLE DECADE COUNTER

New plug-in 1-Mc counter with Nixie numerical readout tube features high reliability through use of beam switching tube; is claimed to be "the only decade counter with provisions for resetting from any position to zero in less than one microsecond." Power requirements are 300 vdc @ 30 ma and 6.3 @ 0.9 amp. —*Burroughs Electronic Tube Div., North Plainfield, N. J.*



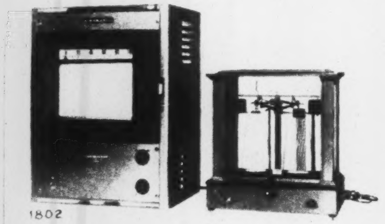
2019

For more information circle **244** on inquiry card.

laboratory equipment

AUTOMATIC RECORDING ANALYTICAL BALANCE

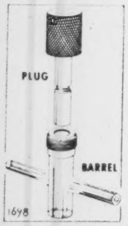
New 200-gram-capacity autographic analytical balance showing instantaneous weight and rate of weight change is expected to open up new fields of research and control. Samples can be placed on pan, or suspended in a controlled environment above or below balance. New balance combines range and accuracy of maker's Analytical Balance with a continuous record and automatic operation: it automatically adds or subtracts weights as required to rescale recorder pen. Range of automatically-controlled weights is 4 grams (40 chart widths) and recording is linear all the way.—*Wm. Ainsworth & Sons, Inc., 2151 Lawrence, Denver 5, Colo.*



1802

For more information circle **245** on inquiry card.

PRECISION-FLOW STOPCOCK



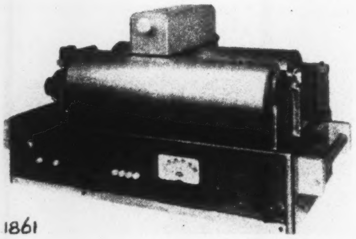
1698

New Vari-Flow glass stopcock with micrometric flow control has threaded plug whose rotation causes it to move axially in threaded barrel, thereby altering alignment of groove with inlet and outlet. Screw action provides tension-free operation, eliminating stiction and plug freezing. Flow characteristics can be changed by altering groove design and varying thread pitch. —*Wilmad Glass Co., Franklin & Flower Sts., Landisville, N. J.*

For more information circle **246** on inquiry card.

PAPER CHROMATOGRAPH SCANNER

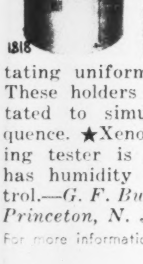
New Model PCS-1, said to be "the only two-dimensional scanner available and the only completely automatic unit of its kind," makes possible rapid and accurate chemical analysis of labeled compounds; detects beta-gamma emitting isotopes; also senses alpha radiation.—*Nuclear Measurements Corp., 2460 N. Arlington Ave., Indianapolis 18, Ind.*



1861

For more information circle **247** on inquiry card.

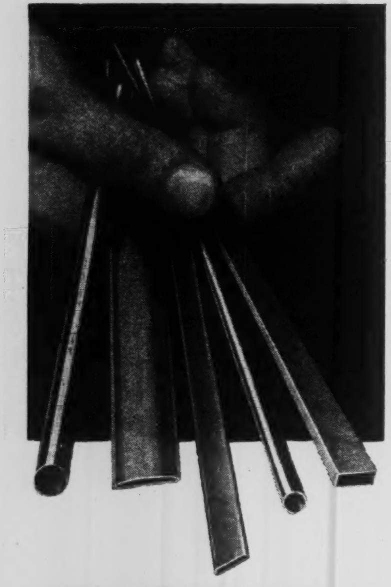
LIGHT-FADING TESTER



1818

New Xenotest PL393 for research, testing, and production control, utilizes a new precisely-constructed xenon lamp with suitable filters, "the best continuous reproduction of natural sunlight in intensity and spectrum." Its automatic operation includes safety controls. 2" x 4" test specimens mount on one or both sides of ten specimen holders on a frame rotating uniformly about xenon lamp. These holders can themselves be rotated to simulate a day-night sequence. ★Xenotest WLP394 weathering tester is generally similar but has humidity and temperature control.—*G. F. Bush Associates, Box 175, Princeton, N. J.*

For more information circle **248** on inquiry card.



Small Tubing

TUBING

.010" TO 1.000" O.D.
PRECISION QUALITY
REGULAR MILL PRICES

Whatever the size, shape or alloy there's a Precision Tube to meet your requirements . . . made to precision specifications yet costs only regular mill prices. Round, rectangular, oval or square, preformed to special shapes . . . in copper, brass, aluminum, nickel, and nickel-alloys, Ni-Span "C", phosphor-bronze and nickel silver.

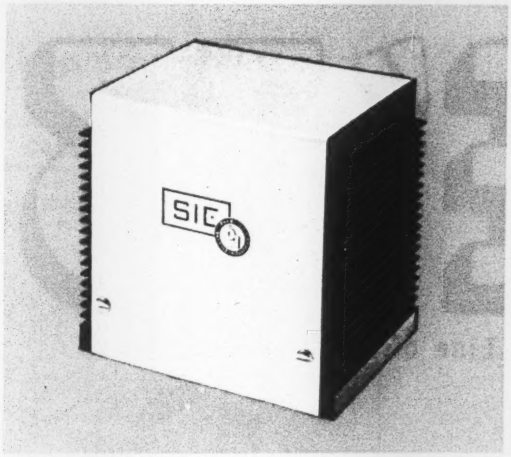
For improved quality at lower costs specify Precision Tubing. It is the tubing consistently unequalled and unsurpassed in comparative quality tests of accuracy, temper, straightness and roundness. It is yours at no extra cost.

Whatever your product plans you can rely on Precision for finish, accuracy and quick deliveries. For information on small tubing and specifications to use in selecting tubing write for the new data book to Department #6, Precision Tube Company, North Wales, Pa.

GET YOUR FREE COPY OF THIS DATA BOOK

PRECISION
TUBE COMPANY

For more information circle **66** on inquiry card.



TPC-2 Specifications

Input Voltage:	12 vdc nominal
Input Current:	6.2 a full load, 0.8 a no load
Maximum Rated Output:	400 ma @ 150 vdc or 200 ma @ 300 vdc
Efficiency:	Better than 80% at full load
Load Regulation:	Less than 15%, No Load to Full Load Less than 8%, One-Half Load to Full Load
Ambient Temperature:	—40° F. to + 150° F.
Ripple:	0.5% full load, RMS basis
Dimensions:	3¾" H x 3²⁵⁄₃₂" L x 2¾" W
Weight:	1¾ lbs.
Price:	$125.00 (F.O.B. Houston, Texas)

There's an SIE Power Supply to meet any application

DC to DC

AC to DC

New circuit developments now enable SIE to offer transistorized power supplies to cover all possible applications: DC to DC, DC to AC and AC to DC; regulated and unregulated, high and low voltage and current ratings, for laboratory, industrial and military installations.

Especially significant is SIE's new circuit which permits operation from DC input voltages above 30 volts without requiring special transistors.

In the 60 watt TPC-2, an ingenious case design permits it to be used in free air without a heat sink, or attached to a heat sink in a confined space.

Check these specifications. They will suggest many new applications for these latest SIE contributions to *Electronic Instrumentation for Industrial Progress.*

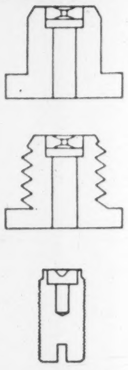
SOUTHWESTERN INDUSTRIAL ELECTRONICS COMPANY

2831 POST OAK ROAD • P O BOX 13058 • HOUSTON, TEXAS

For more information circle **67** on inquiry card.

PRECISION JEWEL BEARING ASSEMBLIES . . .

for AIRCRAFT • ELECTRICAL MECHANICAL and MARINE INSTRUMENTS



Sapphires set in brass, or other metal assemblies made in any quantity to close tolerance specifications are produced by Moser Jewel Company—*manufacturers of industrial jewels for over 50 years.*

Moser also provides highly polished pivots, staffs —silicon and spring loaded assemblies for high shock resistance.

SEND SPECIFICATIONS — DETAILED INFORMATION READILY GIVEN.

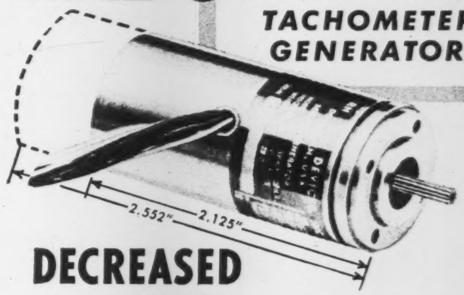
MOSER JEWEL COMPANY

P.O. Box 150 • Perth Amboy, N. J.

"Manufacturers of all types of Industrial Jewels"

For more information circle **68** on inquiry card.

EAD's New Size 11 Servo TACHOMETER GENERATOR



DECREASED SIZE... INCREASED EFFICIENCY

Precision, Performance, Price— Get all 3 at EAD

EAD's precision size 11, 115-volt motor tachometer is now available in a smaller package—and achieves improved electrical characteristics! It delivers 0.6 volts per 1000 rpm with 19 millivolts of total null. Lower nulls are available. Upper temperature reading is 150°C. EAD's new unit is available in variations of voltages and power ratings for transistor operations, variations in shaft and mounting configurations, etc. . . . and may be ordered with precision gear heads to your requirements. Write for more information.

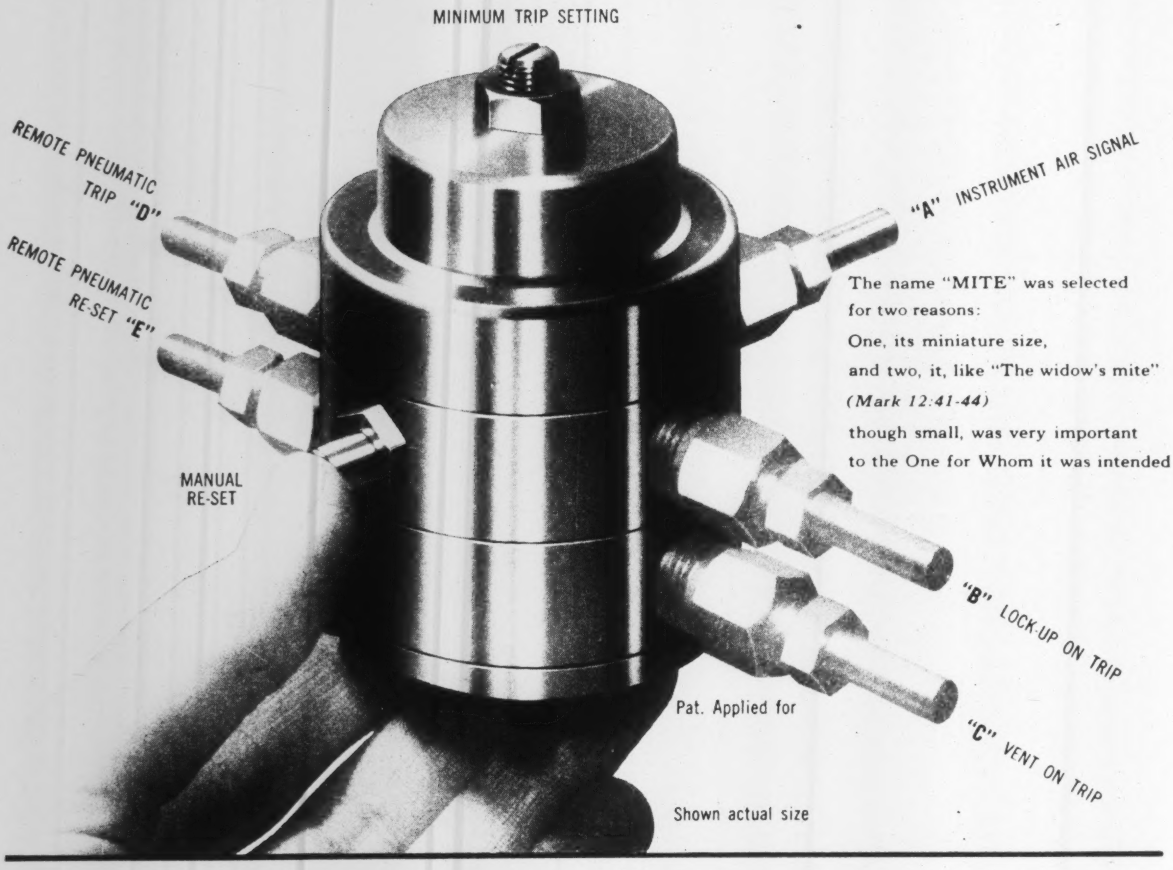
EAD Eastern Air Devices, inc.

347 CENTRAL AVENUE
DOVER, NEW HAMPSHIRE

For more information circle **69** on inquiry card.

"MITE" 73

Announcing the First Item in Our New Line of Control Instruments.


MINIMUM TRIP SETTING
REMOTE PNEUMATIC TRIP "D"
REMOTE PNEUMATIC RE-SET "E"
MANUAL RE-SET
"A" INSTRUMENT AIR SIGNAL
"B" LOCK-UP ON TRIP
"C" VENT ON TRIP

The name "MITE" was selected
for two reasons:
One, its miniature size,
and two, it, like "The widow's mite"
(Mark 12:41-44)
though small, was very important
to the One for Whom it was intended

Pat. Applied for

Shown actual size

The "MITE-73" is a monitor instrument designed to trip when a pneumatic signal violates its minimum or maximum* setting. It remains tripped after the signal is restored to normal limits until manually reset, either locally or remotely. When in service "MITE-73" will relay the input signal "A" to either one or both ports "B" & "C". (Either "B" or "C" must be plugged if not required.)

"MITE-73" is available in anodized aluminum, brass or 18-8 stainless steel.

Standard maximum pressure range 250 P.S.I., minimum trip adjustable 1-100 P.S.I.

From the above graphic description you will note the "MITE-73" has, like the common safety pin, many applications.

*If desirable to have the "MITE-73" trip on a maximum setting, tee off from A to D with a relief valve in the loop and set trip pressure desired.

REPRESENTATIVES IN PRINCIPAL CITIES
Write us for complete technical information, or for the address of our representative in your area.

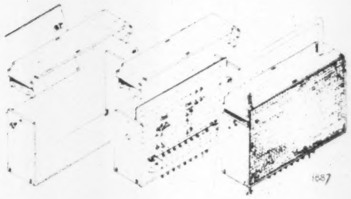
GEORGE W. DAHL COMPANY, INC. 86 TUPELO STREET, BRISTOL, R. I.

For more information circle **70** on inquiry card.

shop equipment and supplies

CASES FOR PLUG-IN UNITS

New Frame-Loc is a unique metal enclosure with all sides flush and with snap-cut side panels maximizing accessibility to wiring. Various sizes and finishes. Internal terminal structures can be printed-circuit panels or maker's "wall," "decks," "turret posts," and can be supplied to order. For ventilation, side panels can be omitted, or perforations can be specified. Various plug types.—*Vector Electronic Co.*, 1100 *Flower St., Glendale* 1, *Calif.*


1687

For more information circle **249** on inquiry card.

WELDING CONTROL

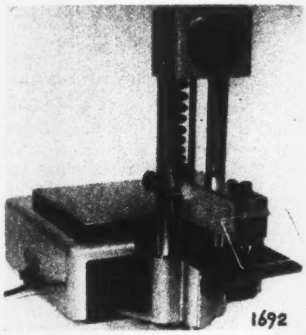
1857

New Model MT 809 Rollectrode automatizes spot welding operations such as attachment of strain gages, thermocouples, thermistors, lead wires, etc., exposed to shock, extreme temperatures, and high wind velocities. Its MIL-spec motor powers a welding wheel over surface to be welded; simultaneously a capacitor-discharge spot welder is automatically triggered.—*Micro-Test, Inc.*, 657 *N. Spaulding Ave., Los Angeles* 36, *Calif.*

For more information circle **250** on inquiry card.

PRINTED CIRCUIT WELDER

New Model 1030 enables welding of components directly to printed or etched wiring boards; features unique ability to make series-type welds: two simultaneous welds from one side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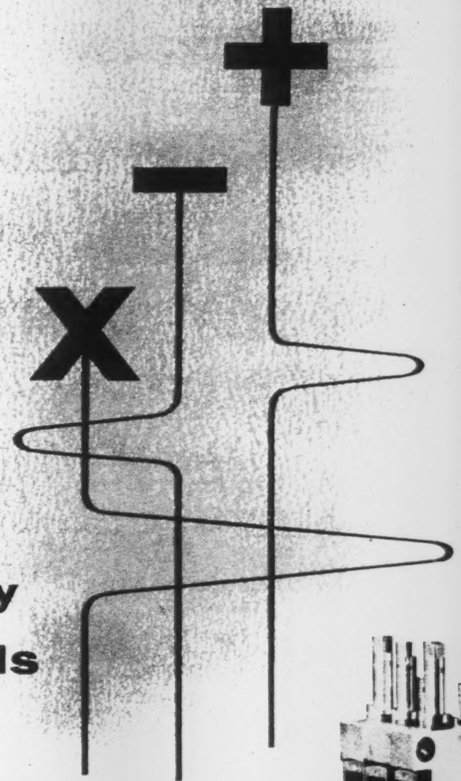
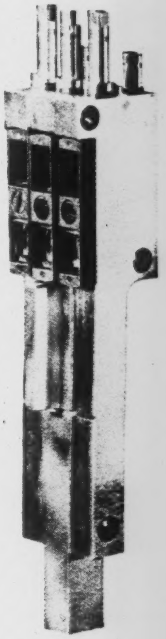


add subtract or multiply two signals

...with CEC's computing galvanometer



Now *all three* basic computations can be performed by one galvanometer . . . two signals can be added, subtracted, or multiplied and the resultant recorded as an oscillographic trace. Ideal for low-level power measurements in electronic equipment, the 7-370 computes instantaneous watts ($P = EI \cos \varnothing$). Its phase sensitivity enables the user to determine power factor, and it can also be used to record sum and difference frequencies. Basic construction consists of a center body housing the moving coil and mirror, with two outside bodies housing stationary field coils and a static reference mirror for marking zero. The 7-370 is compatible with any standard CEC Recording Oscillograph. For further information call your nearest CEC sales and service office, or write for Bulletin CEC 1605-X3.

Transducer Division

Consolidated Electrodynamics CEC

300 North Sierra Madre Villa, Pasadena, California

RECOGNIZED LEADERS IN GALVANOMETERS • TELEMETRY
PRESSURE AND VIBRATION INSTRUMENTATION

For more information circle **71** on inquiry card.

Ceramo®
Thermocouple Wire
Meets
Severe
Conditions

Where Durability, Hi-Temp Resistance Are Needed

"Ceramo" thermocouple wire is designed specifically for severe conditions—conditions where ordinary thermocouple wire is inadequate. "Ceramo" design, pioneered and developed by Thermo Electric, includes thermocouple material conductors with ceramic insulation and overall metal sheathing. Use this versatile wire to solve your problems of high temperature, moisture, abrasion, pressure, chemical or corrosive action, and difficult installation.

For a given application, "Ceramo" will outlast comparable standard types many times — with no significant difference in response. You can form it to almost any shape without shorting or grounding — thus simplifying installation in previously inaccessible spots. "Ceramo" thermocouples can often be used bare where protection tubes would ordinarily be needed. An enclosed hot junction "Ceramo" thermocouple will withstand pressures up to 40,000 psi.

Available Materials

Various "Ceramo" conductors are available for temperatures from −320 F. to 3,000 F. These include I-C, C-C, C-A, Pt. 10% Rh.-Pt., Pt. 13% Rh.-Pt. . . . plus Pt. 30% Rh.-Pt. 6% Rh. Sheathing can be selected to meet the requirements of many different ambient conditions. Standard sheath materials include Stainless types 304, 309, 310, 316 and 347; Inconel; aluminum and copper. Special sheaths are made of titanium, tantalum, Hastalloy C, platinum, Monel, Chromel, Alumel, and copper-nickel alloy.

Available Sizes

Conductors are supplied from 36 to 12 gage. Overall diameters: 2-conductor types — 1/25" to 7/16"; 4-conductor types—1/16" to 7/16". Standard lengths: up to 30 ft. Special lengths: up to 60 ft.

Write For Catalog 31-300- F.

Thermo Electric CO., INC.
SADDLE BROOK, NEW JERSEY

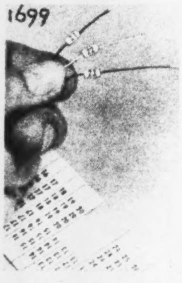
In Canada: THERMO ELECTRIC (Canada) LTD., Brampton, Ont.

For more information circle **72** on inquiry card.

of work; comes complete with power supply, foot pedal, etc. Stepless heat control, 0.1 to 80 watt-seconds, and preset electrode pressure, whence uniform welds.—*Weldmatic, 380 N. Halstead Ave., Pasadena, Calif.*

For more information circle **251** on inquiry card.

WIRE MARKERS



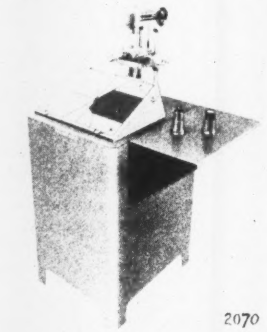
New Self-Adhering E-Z-Code wire markers come on a speed-tab dispenser card that enables user to remove only one at a time. Thousands of stock items available or can be printed to user's requirements, on fabric or aluminum foil for temperatures from −300°F to 300°F. Meets MIL-D-10369B for fungus resistance; also available in vinyl, acetate, glass-cloth, cellophane and paper.—*Westline Products Div., Western Lithograph Co., 600 E. Second St., Los Angeles 54, Calif.*

For more information circle **252** on inquiry card.

dimensional gaging and inspection

MICRO-PROJECTOR

New Wilder Micro-Projector A-F is a floor model, self-contained and self-supporting; available in six selective magnifications and with a choice of centers, surface illumination, protractor, measuring screens, and eight different measuring stages. —*Opto-Metric Tools, Inc., 137 Varick St., New York 13, N. Y.*



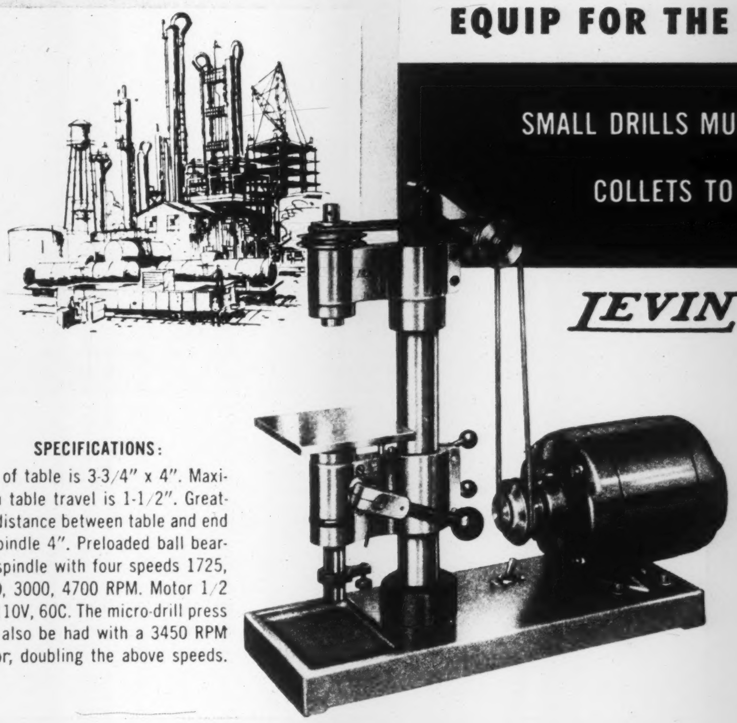
For more information circle **253** on inquiry card.

PRECISION GONIOMETER

New Unisec optical coincidence reading system makes it possible to read shaft positions to one second of arc directly; comes complete with a precision glass circle with 2160

EQUIP FOR THE SIZE OF THE JOB

SMALL DRILLS MUST BE HELD IN PRECISION COLLETS TO ASSURE ACCURACY



LEVIN ® MICRO DRILL PRESS

FOR VERY SMALL HOLES DOWN TO .002"

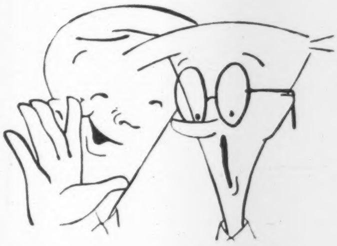
SPECIFICATIONS:

Size of table is 3-3/4" x 4". Maximum table travel is 1-1/2". Greatest distance between table and end of spindle 4". Preloaded ball bearing spindle with four speeds 1725, 2600, 3000, 4700 RPM. Motor 1/2 HP, 110V, 60C. The micro-drill press may also be had with a 3450 RPM motor, doubling the above speeds.

In the LEVIN micro-drill press drills are held in precision collets. Runout is reduced to practically zero and drill breakage from this cause is eliminated. Collets are available in a complete range of sizes down to .1 mm (.004"). **Send for catalog M describing complete line of micro-drilling equipment, collets, instrument lathes and precision tools. Louis Levin & Son, Inc., 3610 S. Broadway, Los Angeles 7, California.**

For more information circle **73** on inquiry card.

need more information...



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100% AUTOMATIC

REMOTE READING

Tank Contents Gauges

- RELIABLE
- NO POWER REQUIRED
- UNDERWRITERS' APPROVED

10000
9000
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7000
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LIQUIDOMETER

Liquidometers use a temperature compensated balanced hydraulic system. Indications unaffected by changes in specific gravity. All models feature large easy-to-read dials. UL approved switches available.

Write for complete details to Dept. E.

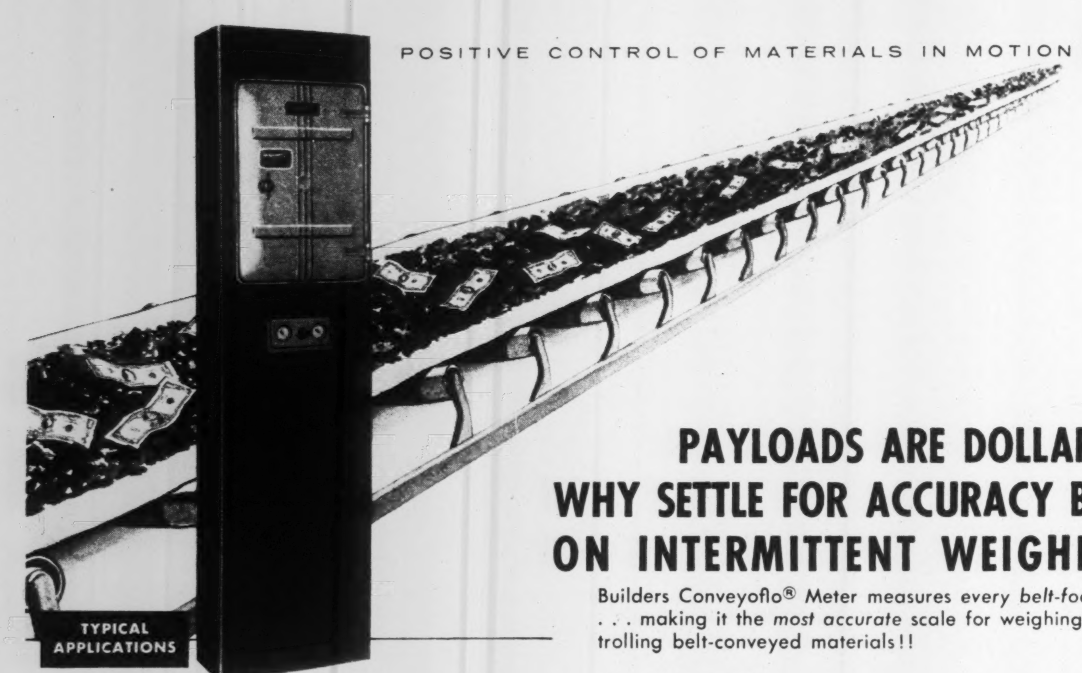
Since 1920 ...of proven quality

THE LIQUIDOMETER CORP.

LONG ISLAND CITY 1, NEW YORK

For more information circle **74** on inquiry card.

POSITIVE CONTROL OF MATERIALS IN MOTION



PAYLOADS ARE DOLLARS... WHY SETTLE FOR ACCURACY BASED ON INTERMITTENT WEIGHING?

Builders Conveyoflo® Meter measures *every belt-foot of load* . . . making it the *most accurate* scale for weighing and controlling belt-conveyed materials!!

HERE'S PROOF!

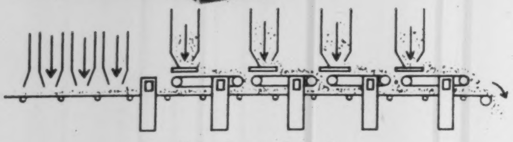
CASE NO. 1: Conveyoflo Meters automatically control the sintering process in a major steel plant.* One phase of operation calls for *one* scale to weigh the ore while *four* other scales automatically control additives. The combined loads from all *five* scales eventually pass over a *sixth* scale. A recent check for a 24-hour run produced the following results:

Total Tonnage from 5 scales	4050.7
Total Tonnage registered by 6th scale	4053.5
Difference (tons)	2.8 or **0.069% . . . ACCURACY!!**

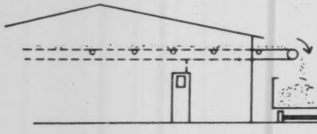
CASE NO. 2: Conveyoflo Meters are used by one of the country's largest producers of power* to inventory incoming coal. On one 17-day run, the totals of two Conveyoflo Meters were compared with the bills of lading with the following results:

Bills of Lading	74,880.4 Tons
Conveyoflo Meter Totals	74,848.0 Tons
Difference	—32.4 Tons or **—0.0432% . . . ACCURACY over a 17-day period.**

*Names and locations upon request!



Sinter Process Control



Freight Car Loading

FEATURES:

- **ACCURACY** . . . within ±0.5 of 1% of full scale load over a 10:1 range.
- **UNLIMITED CAPACITY** . . . each scale individually sized to the specific requirements of the installation.
- **UNAFFECTED BY OVERLOADING** . . . overloading will not damage the live force-balance weigh cell, or cause any shift in calibration of this scale.
- **PNEUMATIC FORCE-BALANCE WEIGH CELL** . . . generates powerful (5 to 15 psi) signals requiring no amplification . . . sensitive, but rugged, simple, and reliable!
- **CONTINUOUS INTEGRATOR** . . . adds and subtracts to provide true zero with empty belt . . . contributes to the exceptional accuracy of Conveyoflo Meters!

Builders-Providence Conveyoflo is designed to fit any standard conveyor. Start saving dollars today. Write for Bulletin 550-P5, **Builders-Providence, Inc., 422 Harris Ave., Providence 1, Rhode Island.**

NEW LITERATURE

Please send me the POSITIVE FLOW CONTROL bulletins checked below:

- ☐ Shuntflo Bulletin (400-J10A) . . . for metering air, gas, steam
- ☐ Propeloflo Bulletin (380-K4B) . . . for metering water
- ☐ Conveyoflo Bulletin (550-P5) . . . for weighing belt-conveyed materials
- ☐ Chronoflo Bulletin (230-H4B) . . . for telemetering and control
- ☐ Venturi Flow Nozzle Bulletin 130-E2A . . . for high pressure, high temperature metering
- ☐ Dall Flow Tube (DFT-P1) Bulletin (125-P3) . . . for low cost, specialized metering

Name

Company

Address

City *State*

BUILDERS-PROVIDENCE
DIVISION OF
B-I-F INDUSTRIES B-I-F METERS FEEDERS CONTROLS

For more information on: Shuntflo circle **75** on inquiry card; Propeloflo circle **139**; Conveyoflo circle **140**; Chronoflo circle **141**; Venturi Flow Nozzle circle **142**; Dall Flow Tube circle **143**.

SPECIFY B-I-F

FLOW METERING ELEMENTS FOR CORROSIVE FLUIDS

Builders Model DFT-PI Dall Flow Tube . . . insert-type, plastic primary metering element. Low cost, accurate. Suitable for most applications, especially corrosive fluids. Bulletin 115-R1.

FOR HIGH PRESSURES & TEMPERATURES

Builders X-TRA-HI Flow Meters . . . for high temperature, high pressure applications . . . proven in primary loop of every major atomic reactor in America. Bulletin 130-E2A.

REMOTE METERING/CONTROL

Builders CHRONO-FLO® Telemeter . . . sends data on remote flows, pressures, temperatures, tank levels, etc. Remotely controls pumps, valves. Bulletin 230-H4B.

LIQUID METERING

Builders PROPELOFLO® Meter . . . direct-reading, propeller-type liquid meter . . . 2″ to 20″ lines . . . within ±2% of actual flow over specified range . . . capacities ranging from 15 to 5,800 GPM. Bulletin 380-K4B.

STEAM, AIR, GAS METERING

Builders Shuntflo Meter . . . self-contained, self-operated meter . . . for 1″ to 24″ line sizes . . . accurate within ±2% of actual rate of flow. Provides continuous and automatic pressure compensation. Bulletin 400-J10A.

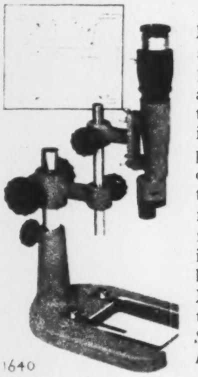
MAIL COUPON TODAY!

1841

graduations; reads both sides of circle at once to remove eccentricity error. Special eyepieces and units for screened projection at high magnification are available, as are special reading systems using larger circles and housings.—*W. & L. E. Gurley, Troy, N. Y.*

For more information circle **254** on inquiry card.

MEASURING MICROSCOPE



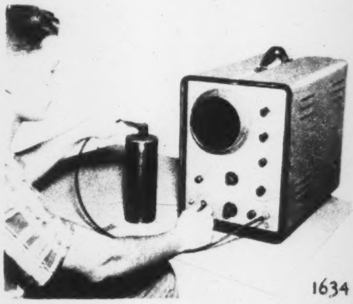
1640

New Direct Measuring Microscope utilizes a pocket comparator at eyepiece to superpose an image of recticle pattern directly on work. Operator thus reads measurements directly from reticle which has both English and Metric graduations.—*Edmund Scientific Co., Barrington, N. J.*

For more information circle **255** on inquiry card.

ULTRASONIC GAGE

New portable Model 501 Echoscope, for ultrasonic inspection, testing and measuring of metals, ceramics and other materials at on-the-spot locations, can be plugged into any standard 110-120-vac outlet; is designed for use in five different operating frequencies utilizing Curtiss-Wright quartz or HiR lithium sulfate transducers; features pattern on its CRT face for measuring size and position of flaws, etc.—*Curtiss-Wright Corp., Industrial and Scientific Products Div., Princeton, N. J.*

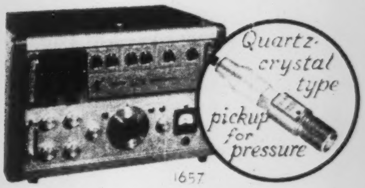


1634

For more information circle **256** on inquiry card.

ENGINE INDICATOR-ANALYZER

New Series EA-114 SLM Engine Indicator-Analyzer measures all internal-combustion engine pressures, vibrations and ignition voltages; provides visual display of engine functions on a standard oscilloscope screen. —*Kistler Instrument Corp., 15 Webster St., North Tonawanda, N. Y.*

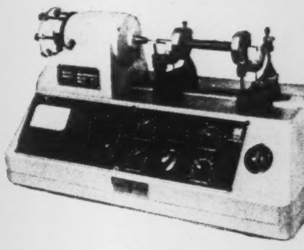


1657

For more information circle **257** on inquiry card.

BALANCING MACHINES

New complete line of Rava Electro-Dynamic Balancing Machines, for production and short run balancing of workpieces from a few ounces to a ton or more, comprises low-cost static-dynamic horizontal balancing machines in which both angle and amount of unbalance are determined quickly by adjusting simple electrical controls. Workpiece is rotated at speeds up to 3600 rpm by a direct motor drive; to 36,000 rpm with an auxiliary frequency converter.—*Tinius Olsen Testing Machine Co., 7544 Easton Road, Willow Grove, Pa.*



For more information circle **258** on inquiry card.

HYDRAULIC TEST STANDS

New Series KC-300 Universal Hydraulic Test Stands feature simplified modular design permitting wide choice of hydraulic circuits without

1656

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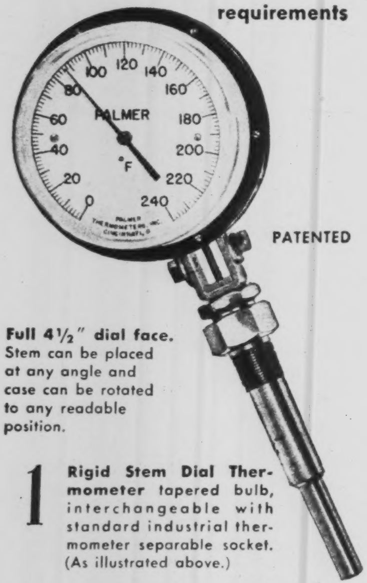
DIAL THERMOMETERS

in 3 types to suit any requirements

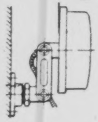


PATENTED

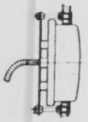
Full 4½" dial face. Stem can be placed at any angle and case can be rotated to any readable position.

1 **Rigid Stem Dial Thermometer** tapered bulb, interchangeable with standard industrial thermometer separable socket. (As illustrated above.)

2 **Wall Mounted Dial Thermometer** with flexible connecting armor. Case adjustable to easy reading position.



3 **Flush Mounted Dial Thermometer** for panel mounting with flexible connecting armor.



All three types have a full 4½" dial face.

for accuracy: Mercury actuated . . . Fully Compensated by Invar Compensaton. Guaranteed Accurate 1 scale division.

for angularity: Can be adjusted to most readable position at any angle desired.

for readability: Bold Black Numbers . . . 11" of scale Reading Dial face can always be placed in easiest readable position.

for interchangeability: Always specify "PALMER" Separable sockets as they are interchangeable for Dial or Industrial type Thermometers.

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Norwood Ave., Cincinnati 12, Ohio
Mfrs. of Industrial Laboratory
Recording and Dial Thermometers

For more information circle **77** on inquiry card.

sacrifice of function or performance. Basic unit limits: 3000 psi and 6 gpm; static test pressures up to 5000 psi available on some models; others to 5000 psi and 20 gpm.—*Kahn & Co., Inc., 543 Windsor St., Hartford 1, Conn.*

For more information circle **259** on inquiry card.

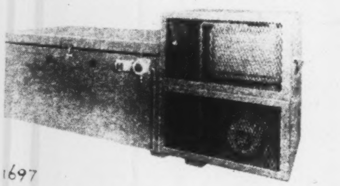
ELASTOMER AGING TESTER

New square design of maker's 28-hole Aluminum Aging Block Model LG (for testing in accordance with ASTM D-865-54T and D-471-55T at temperatures up to 600°F) occupies a square space in either a corner or a row of companion equipment. On special order, square or round Model LG is available for temperatures up to 750°. (Special models: LGH or LGP, up to 1000°F or for pressure-air or oxygen aging).—*Scott Testers, Inc., 45 Blackstone St., Providence, R. I.*

For more information circle **260** on inquiry card.

ENVIRONMENTAL CHAMBER

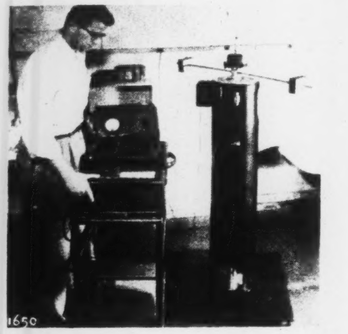
New 16-cu-ft top-opening mechanically-operated self-contained explosion-proof low-temperature environmental chamber has temperature adjustable from ambient to −130°F; inside dimensions 48"x24"x24"; air circulation by externally-mounted explosion-proof motor; thermal capacity 5,800 Btu per hour at −100°F; explosion-proof temperature control with 24-hour or 7-day chart.—*Webber Corp., Dept. EE-653, Box 217, Indianapolis 6, Ind.*


1697

For more information circle **261** on inquiry card.

ANGULAR ACCELERATION AND RATE GENERATOR

New floor model accelerometer and rate gyro tester features frequency and acceleration characteristics infinitely adjustable by sliding weights, by using heavier or lighter weights, or by varying winding of torsion bar that powers generator. Torsion bar itself can be changed (simple operation) for selecting range from 0.5 to 200 rad/sec^2.—*Humphrey Inc., 2805 Canon St., San Diego 6, Calif.*

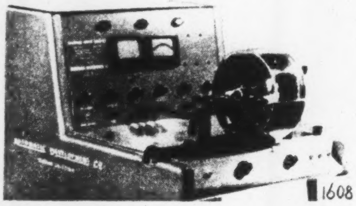

1650

For more information circle **262** on inquiry card.

electrical testing

ELECTRIC MOTOR TESTER

New Model 1061 Electronic Motor Analyzer, for production quality control of ac and dc motors, solenoids, coils, magnetic materials, etc., analyzes for opens, shorts, winding errors, reverse connections, hi-pot to ground, and commutator position. Six to ten components can be tested per minute.—*Automatic Development Co., 2530 N. Naomi St., Burbank, Calif.*


1608

For more information circle **263** on inquiry card.

DIELECTRIC TEST SET

New Model 2 measures dc at voltages up to 100 kv when applied to insulation; features utmost safety, simple operation, reliable performance, excellent output voltage regulation, facilities for voltage and leakage current measurements.—*James G. Biddle Co., 1316 Arch St., Philadelphia 7, Pa.*

1620

For more information circle **264** on inquiry card.

CORE TESTER

New Model 123 Core Tester provides a display of magnetic toroid characteristics: coercive force, saturation flux density, B_R:B_M ratio, differential permeability, and shows

shape of hysteresis loop on a CRO. Principle: current reset, current variable up to 6 amp. Solid rod probe permits manual testing rates up to 400 cores per hour.—*Mack Electronics, 40 Leon St., Boston 15, Mass.*

For more information circle **265** on inquiry card.

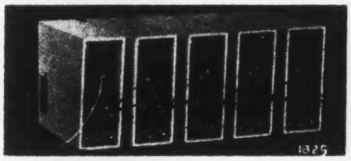
PULSE MODULATOR

New Model 63M hard-tube high-voltage pulse modulator for experimental tube testing is capable of three modes of operation: cathode pulsing, modulating-anode pulsing, and grid pulsing; operates anywhere in range from 30 to 12,000 cps and with pulse lengths continuously variable from 0.5 to 30 usec.—*Levinthal Electronics Products, Inc., Stanford Industrial Park, Palo Alto, Calif.*

For more information circle **266** on inquiry card.

BUILDING-BLOCK TESTERS

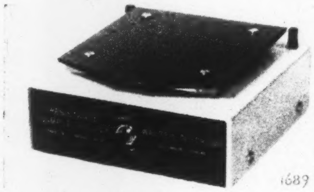
New transistorized digital building-block test-equipment line, for use by engineers involved in development and production of computer systems, features ease of application; high speed (5 megapulses per second); long life reliability; compatibility with most digital circuits; simple method of marginal checking.—*Digital Equipment Corp., Maynard, Mass.*



For more information circle **267** on inquiry card.

RESISTANCE SAMPLE HOLDER

New Type 9 provides a convenient means of measuring both surface and volume resistivities of molded plastics; conforms to ASTM D257-54T; can be used with any resistance-measuring



FOURTH INTERNATIONAL AUTOMATION EXPOSITION and CONGRESS

TECHNICAL SESSIONS

June 10th and 11th—New York Coliseum

Tuesday, June 10th, 9:30 A.M., Coliseum

1. **Importance of Measurements**—Canada Room—Chairman: Douglas M. Considine, Hughes Products Div., Hughes Aircraft Company

Tuesday, June 10th, 2:30 P.M., Coliseum

2. **Product Design for Automation**—Canada Room—Chairman: Robert W. Carson, Managing Editor, Product Engineering.
3. **Automatic Control Valves**—United Nations Room—Chairman: E. Albert Adler, Instrument Engineer, United Engineers & Constructors, Inc.
4. **Military Electronics and Controls**—France Room—Chairman: Cmdr. Claude Morrison, Editor, Military Automation

Wednesday, June 11th, 9:30 A.M., Coliseum

5. **Automatic Weighing**—Canada Room—Chairman: Armand Gaudreau, Consulting Engineer, Gaud-Reau Associates
6. **Manufacturing and Automation**—France Room—Chairman: Stephen Derry, Consulting Management Engineer

Wednesday, June 11th, 2:30 P.M., Coliseum

7. **Medical Instrumentation**—Canada Room—Chairman: Dr. Raymond Jonnard, Assistant Director, Laboratory, Prudential Insurance Company of America
8. **Data Acquisition & Reduction**—United Nations Room—Chairman: Ward O'Connor, Chief Mechanical Engineer, Lummus Company

Thursday, June 12th, 9:30 A.M., Coliseum

9. **Education for Automation**—Canada Room—Chairman: Milton H. Aronson, Editor, Instruments and Automation.

COOPERATING SOCIETIES

American Society of Mechanical Engineers, Materials Handling Division—Theme of Meeting: Materials Handling as a Key to Industrial Automation

Tuesday, June 10th, 9:30 A.M., Coliseum

Automatic Warehousing—South America Room—Chairman: To be announced

Tuesday, June 10th, 2:30 P.M., Coliseum

Automatic Materials Handling System in Small Plants and Warehouses—South America Room—Chairman: To be announced

Wednesday, June 11th, 9:30 A.M., Coliseum

Automation on the Production Line—South America Room—Chairman. To be announced.

Wednesday, June 11th, 2:30 P.M., Coliseum

Systems Engineering, Economy and Justification—South America Room—Chairman: To be announced

l'Association Internationale de Cybernetique

Wednesday, June 11th, 2:30 P.M., Coliseum

Contributions of Cybernetics to Automation—France Room—Chairman: Dr. George Boulanger, Professor, Polytechnique de Mons and l'Universite de Bruxelles; President l'Association Internationale de Cybernetique

See page 657 for registration information

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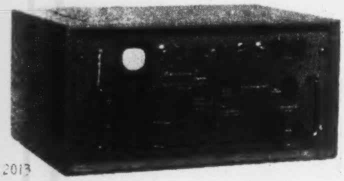
equipment to determine volume and surface resistivities to at least 10^{17} ohm-centimeters or ohms per square. —*Walter N. Trump, 516 S. Vermont Ave., Columbus, Kansas.*

For more information circle **268** on inquiry card.

COMPUTING TRANSFER OSCILLATOR

New Model 7580 measures cw and pulsed frequencies without manual calculations using harmonic multiplying factor; extends range of maker's 10-Mc EPUT(R) Meters to beyond 12 kMc. Accuracies to 3 parts in 10^7.—*Berkeley Div., Beckman Instruments, Inc., 2200 Wright Ave., Richmond 3, Calif.*


2013

For more information circle **269** on inquiry card.

POLARITY TESTER

New Model R rapidly determines polarity of all types of transformers —power, distribution, through and split-core current transformers; is powered by three standard dry cells and is a simple and extremely convenient "package"; is designed to withstand the most adverse service conditions.—*J. W. Dice Co., Englewood, N. J.*

For more information circle **270** on inquiry card.

RESISTANCE DEVIATION BRIDGE

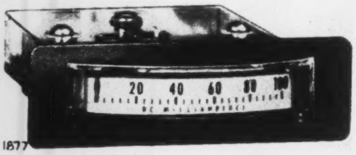
New Model 957 indicates percentage deviation of a sample resistor from standard resistor of the same nominal value; can be used as a precision resistance bridge for general measurement by null method; can also be adapted for use as control unit in automatic sorting or inspecting. Accuracy as a limit bridge is better than 0.05% for resistances greater than 10 ohms. Unique circuit requires no balancing or zeroing controls. Case can fit into a standard relay rack.—*Millitest Co., 88 Madison Ave., Hempstead, N. Y.*

For more information circle **271** on inquiry card.

electrical and electronic instruments

EDGEWISE INSTRUMENTS

New Models 1502 and 1507 provide visibility of a conventional 2½" instrument but take half panel space and weigh about 5 oz; use maker's Self-Shielded core magnet movement; are accurate to 2% of full-scale deflection in dc ranges. Carried in stock in fifteen ranges and types.—*Simpson Electric Co., 5200 W. Kinzie St., Chicago 44, Ill.*



1877

For more information circle **272** on inquiry card.

POTENTIOMETER

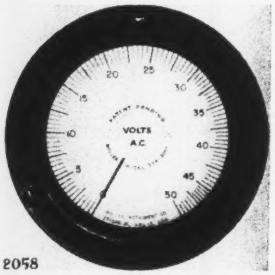
New Oelke-Grinnell Potentiometer, said to be "ideal for buyers with a budget," has a rugged standard cell. Its novel circuit permits checking slide-wire calibration in seconds without resetting slide wire. Double range 0-1 and 1-2 v, direct reading to mv and estimation of fourth decimal place.—*Wilkens-Anderson Co., 4525 W. Division St., Chicago 51, Ill.*

OELKE-GRINNELL POTENTIOMETER
WILKENS-ANDERSON
1893

For more information circle **273** on inquiry card.

300° SCALE INSTRUMENTS

New 4½" round or square instruments have more than 8½" of usable linear scale. Knife-edge pointer moves 300° (15% more than in 250° instruments which company also makes). Response time and damping are four to five times faster than ordinary 90° instruments, surpassing MIL spec 10304A. Standard ranges from 100 microamps up.—*Miller Instrument Co., Inc., 165 E. Lincoln St., Escondido, Calif.*



2058

For more information circle **274** on inquiry card.

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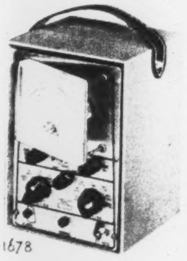
For more information circle **87** on inquiry card.

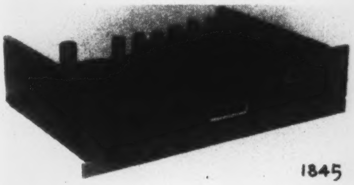
PRINTED-CIRCUIT VTVM


1678

New Model 902 printed-circuit voltage-regulated vacuum-tube voltmeter has 28 ranges; permits user to tilt indicator to eye line at any angle for more accurate readings; has a "Magic Lead Switch" that automatically shorts or opens test leads for zero and infinite ohms adjust.—*Precise Development Corp., 2 Neil Court, Oceanside, N. Y.*

For more information circle **275** on inquiry card.

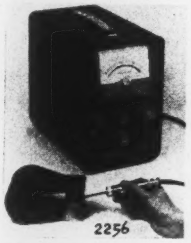
RACK-MOUNTED DIGITAL VO's


1845

New extremely rugged rack-mounted VTVM's feature high input impedance, moderate cost, illuminated decimal point moving with position of range switch, and red illuminated signal indicating when next higher scale should be selected.—*Hycon Electronics, Inc., 321 S. Arroyo Parkway, Pasadena, Calif.*

For more information circle **276** on inquiry card.

TRANSISTORIZED GAUSSMETER


2256

New Model 1295 Gaussmeter utilizes Hall effect to measure magnetic flux densities up to 50,000 gauss in static or ac fields to 3% accuracy. Nine ranges cover 0-100 to 0-50,000 gauss. Two standard magnets of 1000 and 5000 gauss calibrated to 1% are included. Use of transistors throughout eliminates warm-up drift and provides stable operation. Operates on 117 v, 50-400 cps.—*Radio Frequency Laboratories, Inc., Powerville Rd., Boonton (Twp.), N. J.*

For more information circle **277** on inquiry card.

5" OSCILLOSCOPE

New Model 586 Low Frequency Oscilloscope, helpful in eliminating possible galvanometer damage due to accidental overload or wrong connections when setting up or calibrating recording instruments, can be ob-

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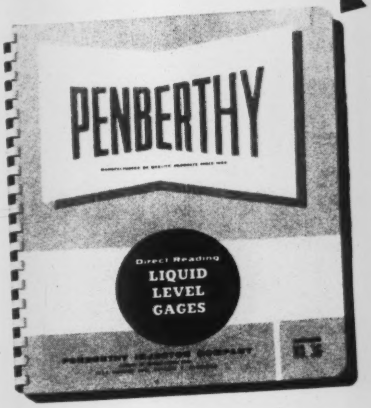

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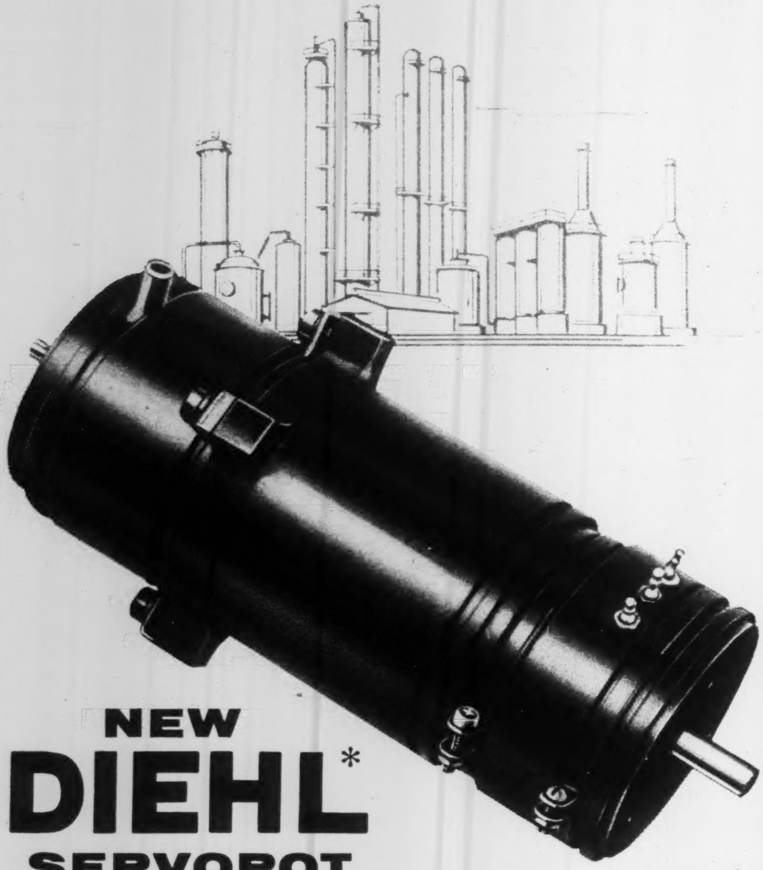
COMPANY__________

For more information circle **88** on inquiry card.



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The SERVOPOT finds wide application in balancing, positioning and computing servos. Addition of an integrally-mounted DIEHL 0.5% A.C. tachometer makes the SERVOPOT *a complete integrating servo.*

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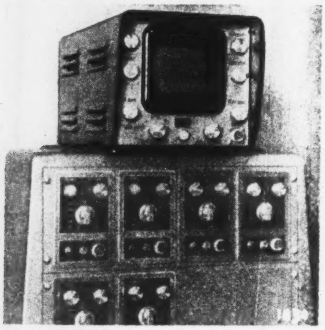
For more information circle **76** on inquiry card.

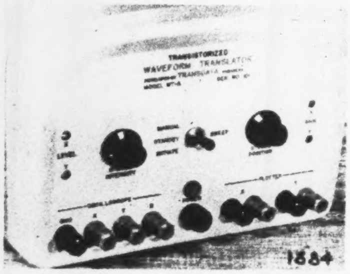


served by groups of people from wide angles. Available in single- or multiple-channel scanning.—*Edin Co., Inc., 207 Main St., Worcester 8, Mass.*

For more information circle **278** on inquiry card.

WAVEFORM TRANSLATOR

New Waveform Translator for study of repetitive waveforms permits accurate plotting of waveforms to



20 kc on conventional *X-Y* plotters. It can plot complex Lissajous patterns, hysteresis loops, complete families of curves, etc.—*Transdata, 1844 Brigden Rd., Pasadena, Calif.*

For more information circle **279** on inquiry card.

electrical-instrument accessories

LOW-THERMAL EXTERNAL-COIL MINIATURE CHOPPER

New low-noise miniature Syncroverter chopper featuring low thermal construction is particularly useful in chopper-stabilized dc amplifiers where thermal stability and extremely low noise are of prime importance. It offers the same contact ratings and reliability in dry circuit applications as does company's standard external coil units. Complete electrostatic shielding of coil from contact assembly results in extremely low residual noise levels. Modular construction makes available interchangeable coils optimized for minimal power drive and thermal dissipation at preselected frequencies.—*The Bristol Company, Waterbury 20, Conn.*

For more information circle **280** on inquiry card.

DECADE CAPACITANCE UNITS

1838

New Types 980-G and 980-H are new assemblies of Type 505 capacitors to furnish decades of 0.01 uf and 0.001 uf per step, respectively. New Type 980-P1 Switch, used in these decades and also available separately, is a low-capacitance, low-loss unit. Illustrated: Type 1419-K assembly of three decades with max capacitance of 1.11 uf in steps of 0.001 uf, suitable for use as a secondary standard.—*General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.*

For more information circle **281** on inquiry card.

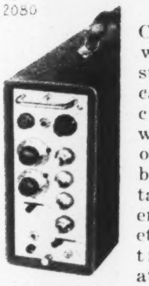
VARIABLE TRANSFORMERS

New line of quality variable transformers is announced. First unit is 1.5-amp Model VT1R5; others will soon follow. All achieve high efficiency through unique core design. Other features: (1) Brush arm carries no current; a pigtail shunts current from brush directly to a large copper graphite slip ring; (2) internal stop prevents damage to brush and brush arm; (3) heavy rhodium plating on brush track; (4) reversible direct-reading dial.—*Ohmite Mfg. Co., 3667 Howard St., Skokie, Ill.*

1670

For more information circle **282** on inquiry card.

CARRIER PREAMPLIFIER

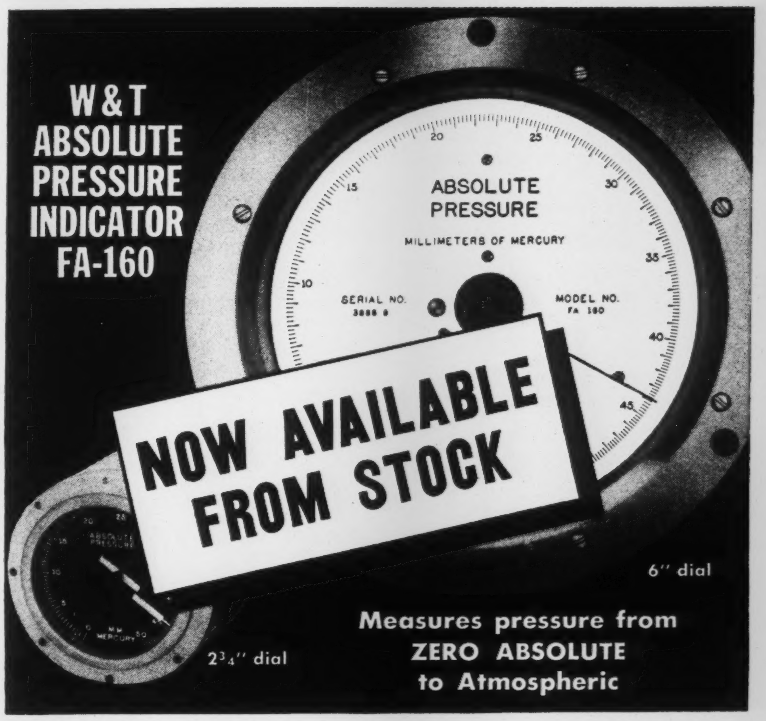

2080

New Model 450-1100 Carrier Preamplifier with integral power supply can drive optical systems, tape recorders, 'scopes, etc.; will excite and accept outputs of resistance bridge, variable-reluctance pickups, differential transformers, etc. Front panel controls include attenuator, calibration factor dial, calibration signal pushbutton, zero suppression, smooth gain, position and balance controls. Standard carrier frequency 2400 cps (600, 1200 and 4800 cps optional).—*Sanborn Co., Industrial Div., 175 Wyman St., Waltham 54, Mass.*

For more information circle **283** on inquiry card.

DC AMPLIFIER

New Model 1250 uses a unique signal compression method to prevent loss of data resulting from unexpected



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Accuracy: 1/300 of full scale
Sensitivity: 1/500 in *all* ranges
Ranges: 0-50mm Hg. 0-100mm Hg. 0-200mm Hg. 0-410mm Hg. 0-800mm Hg. 390-800mm Hg.
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Write for Publication No. TP-28-A

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For more information on: Pressure Indicator circle **81** on inquiry card; Scale Meters circle **144**.

HASTINGS VACUUM GAUGES

SET NEW STANDARDS OF ACCURACY, STABILITY, RESPONSE

MODEL LV-1

- Easy To Read Scales
- Unusually Long Life
- Matched Gauge Tubes
- No Outgassing Or System Contamination

NEW (MODEL LV-1.) Measures 0-100 micron Hg. Single meter; large 4" scale indicates vacuum directly without adjustments. Internal voltage regulator takes care of fluctuations in line voltage. Ideal for Industrial Installations. Also available in 0-1000 micron and 0.1-20 mm Hg. ranges.

MODEL GV-3 VACUUM GAUGE

(Shown at right with optional 5-position switching attachment) Range from 0-1000 microns Hg. Manual current set and additional milliampere scale allow adjustment for use in presence of gases other than air, for leak detection, and for specialized laboratory use.

Evaluation by Users

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For more information circle 82 on inquiry card.

UNIFLOW Springless type 500 air to open — air to close — 1/2" to 12" pneumatic or electric pneumatic

with positioner

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Uniflow

Presents the most complete line of Saunders patent type air operated control Valves.

In chemical, slurry, water treating and high vacuum installations, UNIFLOW Valves have fast become the most popular because not only are they low in cost, but highest quality requirements are met and maintained.

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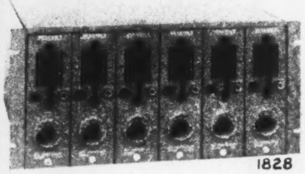
For more information circle 83 on inquiry card.

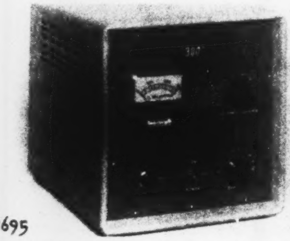

1828

over-scale input signals; features low noise level (3 uv) for 30 kc bandwidth. Voltage gain 1000; 2-uv zero stability.—*Dynamics Instrumentation Co., 1118 Mission St., S. Pasadena, Calif.*

For more information circle 284 on inquiry card.

LINEAR AMPLIFIER

New fully-shielded Vantron 300, capable of high power operation on CW, AM and SSB, is suited for single side-band operation; features least number of tuning adjustments, stability on all bands.—*Transitron, Inc., 186 Granite St., Manchester, N. H.*


1695

For more information circle 285 on inquiry card.

electrical and electronic components

SILICON TRANSISTORS

New ST400 and 2N389 high-power 60-v silicon transistors with ratings to 80 watts feature low R_{cs} (typically 1.5 ohm) enabling them to operate at currents to 5 amp. Especially useful in servo-amplifiers, relay drivers, power switching applications, voltage regulators, etc.—*Transitron Electronic Corp., Wakefield, Mass.*

For more information circle 286 on inquiry card.

H F POWER TRANSISTORS

New transistors with power gain cutoff frequencies greater than 20 kc can faithfully reproduce entire audible range; are said to combine for the first time all the characteristics necessary in design of true hi-fi amplifiers: 27-33 db of power gain (14-v supply) at 2 watts output, 10 watts dissipation at 70°C base temperature, etc.; also afford advantages in certain digital computers and other fast-switching applications. —*Clevite Transistor Products, Waltham, Mass.*

For more information circle 287 on inquiry card.

SILICON RECTIFIERS

Eighteen new types of very-high-voltage (1500-16,000) cartridge silicon rectifiers, Series 1N1133 to 1N1149, operate at temperatures to 150° C; meet or exceed EIA specs; are vibration-safe and shock-resistant as a result of junction-bonding method of assembly.—*Pacific Semiconductors, Inc., 10451 W. Jefferson Blvd., Culver City, Calif.*

For more information circle **288** on industry card.

REGULATOR TUBES

2095

New Series GV6C corona type regulators, for voltages from 3500 to 6000, supplement and extend usefulness of maker's GV5C series; are especially designed for military and other applications requiring reliable performance and long operational life, even under conditions of ambient temperatures from −55°C to 85°C.—*The Victoreen Instrument Co., Components Div., 5806 Hough Ave., Cleveland 3, Ohio.*

For more information circle **289** on industry card.

SILICON DIODES

Five new high-current silicon pigtail diodes, Types 1N536 through 1N540, feature excellent forward and reverse characteristics, whence high rectification efficiency. They are rated at 750 ma @ 50°C, and 250 ma @ 150°C ambient, with peak inverse voltage ratings of 50, 100, 200, 300 and 400 respectively. Max full-load average voltage drop is 0.5; max leakage current 0.4 ma (full cycle average at 150°C). Physically: all-welded hermetically-sealed shockproof housings with pigtail leads welded to terminals.—*Int'l Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif.*

For more information circle **290** on industry card.

CONTROLLED RECTIFIER

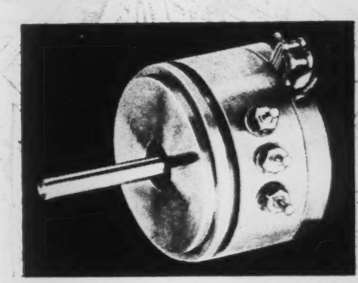
Actual size
2036

New silicon controlled rectifier features unique ability both to change ac to dc and simultaneously to control volume of power fed into a load. Current developmental models can handle loads from 200 to 1000 watts at a stud temperature of 125°C. When switching at full rating, new controlled rectifier dissipates only 0.5% of controlled power.—*General Electric Co., Semiconductor Products Dept., Syracuse, N. Y.*

For more information circle **291** on industry card.

RELIABILITY
INSIDE
THE
BLACK BOX*

FAIRCHILD'S POTS ARE TORTURE TESTED



ONLY FAIRCHILD TORTURE-TESTS
1 out of every 100 Production Units

Check These Additional Fairchild Reliability Features:

- ✓ **FAIRCHILD** tests a 1% Quality Control sampling from Production runs. These random sample units are fully tested under all environmental conditions to insure their reliability.
- ✓ **FAIRCHILD** has complete environmental test facilities and does not depend upon outside laboratories for these tests.
- ✓ **FAIRCHILD** Type tests as well as Quality Control tests are conducted under Air Force surveillance and with approved facilities.
- ✓ **FAIRCHILD** development units are tested to complete environmental exposure before they are released to the Production Department.
- ✓ **FAIRCHILD** makes use of pilot production runs to insure performance before full schedule production runs are made
- ✓ **FAIRCHILD** has a complete inspection set up including incoming, winding, line and sub assembly inspection and 100% final inspection against customers drawings and specifications.
- ✓ **FAIRCHILD** Engineering sets up standards for materials and purchased parts in order to meet reliability requirements.
- ✓ **FAIRCHILD** has three modern air-conditioned plants.

Only Fairchild Linear and Non-Linear Pots incorporate all of the above Reliability features. These High Reliability units can be had in 3/8" to 5" diameters, single and multi-turn, in standard and high temp versions and with accuracies as high as .009%.

For more information write Dept. 14A.

RELIABILITY
INSIDE
THE
BLACK BOX

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Potentiometers • Gyros • Pressure Transducers • Accelerometers

✱ Built-in SAFETY FACTORS beyond the specs for reliability in Performance.

For more information circle **84** on inquiry card.

PUT
YOUR TANK FARM
AT YOUR
FINGERTIP–

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TANK FOOT INCH

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FOR REMOTELY INDICATING:

Liquid Level to 1/8" increments
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***Pressure**

ADDITIONAL FEATURES INCLUDE:

Fingertip **Control** of electric motor or solenoid operated valves, etc.
Automatic **Tank Scanning** at predetermined intervals for liquid level and temperature.
Receiver Output suitable for automatic data logging equipment.

**These two items are available on special order only and indicate the versatility of the Pulse Code Telemetering Systems. Write for Bulletin CP-3012 on "Varec" PULSE CODE Telemetering.*

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For more information circle **85** on inquiry card.

electromechanical components

RELAYS WITH REMOVABLE DUST COVER

New removable metal enclosures are available for Class 22 Relays, when mounted on customer's strip, panel or chassis.—*Magnecraft Electric Co., 3350L W. Grand Ave., Chicago* 51, *Ill.*

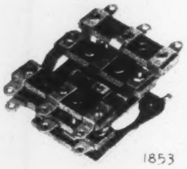
For more information circle **292** on inquiry card.

HIGH TEMPERATURE RELAY

New improved PW sensitive miniature-tube sp-dt relay has high shock and vibration resistance, can operate up to 125°C or 257°F. It operates on 40 milliwatts under 30-G shocks and 10-G vibrations to 500 cps. Where high shock and vibration resistance is not required, it will operate on 25 mw. It will control up to 6 amp. Balanced armature permits mounting in any position.—*Potter & Brumfield, Inc., Princeton, Ind.*

For more information circle **293** on inquiry card.

FIVE-POLE POWER RELAY

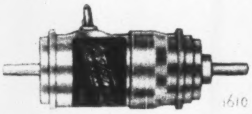

1853

New 400-cps Series 26 features 5p-dt contacts, 125°C operation, high voltage breakdown; available in both open and hermetically sealed versions.—*Kurman Electric Co.,* 191 *Newel St., Brooklyn, N. Y.*

For more information circle **294** on inquiry card.

MINIATURE CLUTCH

New Model CF electromagnetic clutch features fast response, zero blacklash, high efficiency per unit weight, and vibration resistance per MIL-E-5272A; operates on dc and will perform efficiently on full-wave rectified ac without filtering. Four sizes with minimal torque ratings of 2, 8, 16 and 32 ounce-inches. Special voltage, mounting methods and shaft configurations can be provided.—*Autotronics Inc., Rt.* 1, *Box* 812, *Florissant, Missouri.*


1610

For more information circle **295** on inquiry card.

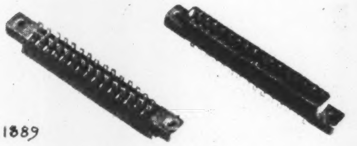
SMALL HIGH-TORQUE MOTOR

New high-torque miniature Actuator Motor operates between −100°F and 500°F at 60 or 400 cps ac or pulsating dc; starts and stops "in a microsecond" and starting torque is equal to running torque. Among applications: rotary selector for wafer, coaxial or other types of switches; remote control switching and homing devices; valve operation; electric counters; power stepping switches; indexing devices.—*The Viking Tool and Machine Corp., 20 Main St., Belleville 9, N. J.*

For more information circle **296** on inquiry card.

PRINTED CIRCUIT CONNECTOR

New connector's receptacle features floating bobbins which compensate for any misalignment between it and printed board: when misaligned board strikes chamfer at each end and along inside edge of receptacle cavity, receptacle shifts on its bobbins and allows board to enter cavity. Available in 10, 15, 22 and 28 single-row contacts and 30 and 44 double-row contacts.—*Viking Industries, Inc., 21343 Roscoe Blvd., Canoga Park 2, Calif.*

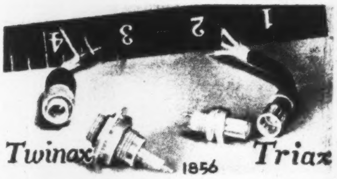


1889

For more information circle **297** on inquiry card.

MICROMINIATURE CABLES AND CONNECTORS

New "Twinax" consists of 160-ohm, low capacitance and two shielded and jacketed conductors; connector is slide-on type keyed for polarity. ★New "Triax" is 50-ohm double-shielded coax with insulation between shields and is jacketed; connector is screw-type.—*Microdot, Inc., 220 Pasadena Ave., South Pasadena, Calif.*



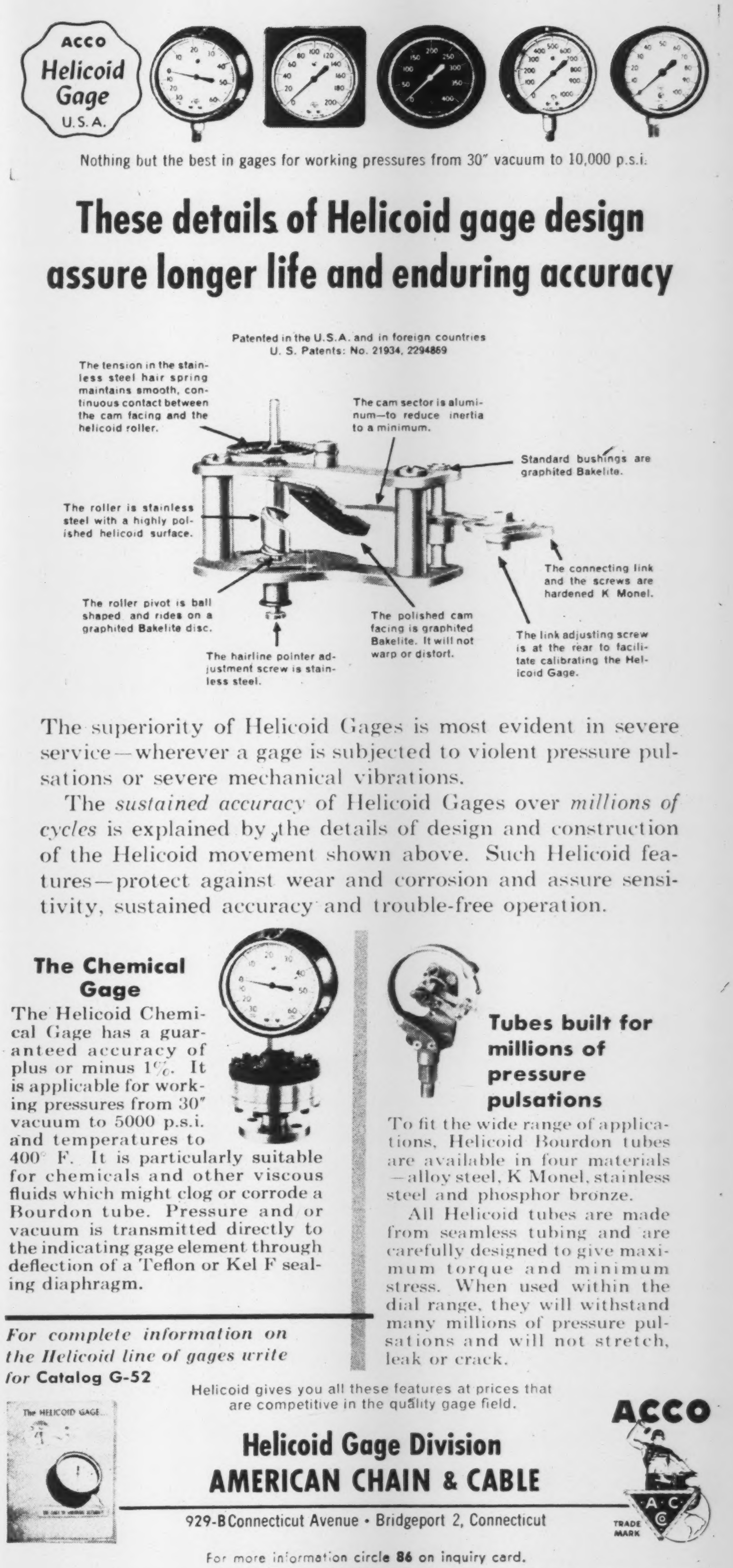
1856

For more information circle **298** on inquiry card.

STANDOFF TERMINAL

New insulated standoff electrical terminal is the first to operate at 1000°C and will also maintain its electrical function in an environment in which electronic equipment will operate in conjunction with a nuclear power source. High-strength non-brittle alumina insulator withstands over 1000°C and 400,000 pis compression. Resistivity at 25°C is greater than 10^{14} ohms/cm^3; at 900°C, 4×10^5 ohms/cm^3.—*Litton Industries Components Div., 5873 Rodeo Rd., Los Angeles 16, Calif.*

For more information circle **299** on inquiry card.


ACCO
Helicoid
Gage
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Nothing but the best in gages for working pressures from 30" vacuum to 10,000 p.s.i.

These details of Helicoid gage design assure longer life and enduring accuracy

Patented in the U.S.A. and in foreign countries
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The tension in the stainless steel hair spring maintains smooth, continuous contact between the cam facing and the helicoid roller.

The cam sector is aluminum—to reduce inertia to a minimum.

Standard bushings are graphited Bakelite.

The roller is stainless steel with a highly polished helicoid surface.

The connecting link and the screws are hardened K Monel.

The roller pivot is ball shaped and rides on a graphited Bakelite disc.

The polished cam facing is graphited Bakelite. It will not warp or distort.

The link adjusting screw is at the rear to facilitate calibrating the Helicoid Gage.

The hairline pointer adjustment screw is stainless steel.

The superiority of Helicoid Gages is most evident in severe service—wherever a gage is subjected to violent pressure pulsations or severe mechanical vibrations.

The *sustained accuracy* of Helicoid Gages over *millions of cycles* is explained by the details of design and construction of the Helicoid movement shown above. Such Helicoid features—protect against wear and corrosion and assure sensitivity, sustained accuracy and trouble-free operation.

The Chemical Gage

The Helicoid Chemical Gage has a guaranteed accuracy of plus or minus 1%. It is applicable for working pressures from 30" vacuum to 5000 p.s.i. and temperatures to 400° F. It is particularly suitable for chemicals and other viscous fluids which might clog or corrode a Bourdon tube. Pressure and or vacuum is transmitted directly to the indicating gage element through deflection of a Teflon or Kel F sealing diaphragm.

Tubes built for millions of pressure pulsations

To fit the wide range of applications, Helicoid Bourdon tubes are available in four materials—alloy steel, K Monel, stainless steel and phosphor bronze.

All Helicoid tubes are made from seamless tubing and are carefully designed to give maximum torque and minimum stress. When used within the dial range, they will withstand many millions of pressure pulsations and will not stretch, leak or crack.

For complete information on the Helicoid line of gages write for **Catalog G-52**

The HELICOID GAGE...

Helicoid gives you all these features at prices that are competitive in the quality gage field.

ACCO
TRADE MARK

Helicoid Gage Division
AMERICAN CHAIN & CABLE
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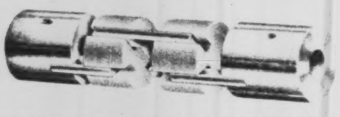
For more information circle **86** on inquiry card.

mechanical components

MINIATURE COUPLING

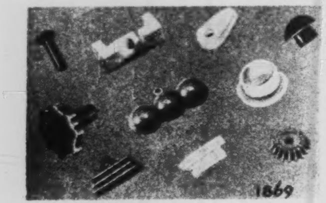
New "Maxflex" for servo and instrument applications accommodates $\frac{1}{16}$″ radial, $\frac{1}{16}$″ axial and 15° angular misalignment without backlash or error; obviates tight location tolerances, utilizes balanced-construction universal joints with no springs, pivots or point contacts. Available in ¼″ male, ⅛″ and $\frac{3}{16}$″ female.—*Parametrics, P. O. Box 629, Costa Mesa, Calif.*



For more information circle **300** on inquiry card.

MINIATURE MOLDED PARTS

New "Pee-Wee" plastic injection molding process makes available tiny precision custom-molded parts in quantities of 100 or more, in thermoplastic material such as Nylon, polystyrene, polyethylene, etc. Max length 1¼″; max weight 3½ grams (⅛ ounce); min wall thickness is 0.008″. —*Pee-Wee Molding Corp., 1720 Atlantic Ave., Brooklyn 13, N. Y.*



1869

For more information circle **301** on inquiry card.

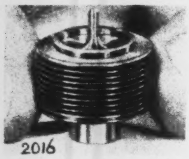
COMPRESSION FITTINGS

New Presslok Nylon fittings provide an anti-corrosive positive anchor as original or replacement components, in hydraulic and pneumatic applications using brass, copper, aluminum, steel or Nylon tubing, without damaging or distorting the tubing; stand up under 1200 psi; feature easy installation in seconds after hole is drilled. Available in 7 OD sizes from ⅛″ to ½″.—*Nylon Molding Corp., 141 South Ave., Garwood, N. J.*

2068

For more information circle **302** on inquiry card.

EXPANSION BELLOWS



2016

New line of expansion bellows for volumetric displacement applications (such as absorbing expansion of oil in filled systems) combines great flexibility with low spring rates and low stress, permitting volumetric size " reduction of 50% or more over conventional types." Illustrated is a ¾″ OD unit, 0.084″ solid height, spring rate 20 lb/in, providing a total displacement of 0.5 cu in. Larger sizes up to 700 cu in displacement.—*Belfab Corp., Agawam, Mass.*

For more information circle **303** on inquiry card.

valves, etc.

SOLENOID VALVES

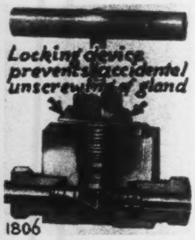
1886

New SV-4900 low-cost multi-purpose 2-way (normally closed) solenoid valves feature a unique plunger seal design with a soft rubber seal which assures bubble-tight sealing; are available in $\frac{7}{64}$″ orifice rated at 130 psi max, and $\frac{5}{32}$″ rated 60 psi max.—*Valcor Engineering Corp., Carnegie Ave., Kenilworth, N. J.*

For more information circle **304** on inquiry card.

QUICK-ASSEMBLY H-P VALVES, FITTINGS AND TUBING

New Quick Connect Ermeto stainless-steel valves and fittings for fast assembly and high-pressure set-ups to 10,000 psi reduce set-up time; require no threading or beveling: tubing is cut to desired length and inserted into opening; a nut and an internal sleeve lock tubing securely, completing assembly. With proper care, joints can be made and broken many times without impairing efficiency of joint.—*American Instrument Co., 8030 Georgia Ave., Silver Spring, Md.*

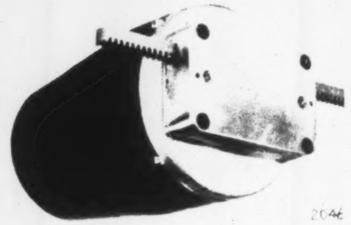


1806

For more information circle **305** on inquiry card.

LINEAR ACTUATOR

New Lineatrol positions valve or other final element in exact proportion to a control signal. It comprises a gearmotor with a built-in pot resistor to produce a remote indication of position or for use in automatic control circuits. Thrust forces up to 1000 lbs; wide variety of stroke lengths and stroking rates. Lineatrol can be furnished without built-in pot resistor.—*The Jordan Co., 3235 W. Hampton Ave., Milwaukee 9, Wis.*



2046

For more information circle **306** on inquiry card.

nucleonics

ROOM-AIR MONITOR

New instrument designed for monitoring room air to detect presence of minute quantities of radioactivity will detect alpha, beta, and gamma radiations, utilizes a Beckman Model V micromicroammeter which can monitor air samples from up to 20 rooms.—*Beckman Process Instruments Div., 2500 Fullerton Rd., Fullerton, Calif.*

For more information circle **307** on inquiry card.

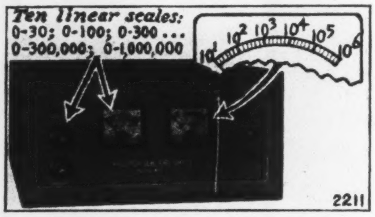
MONITORING SYSTEM

New RAM (Remote Area Monitoring) system gives automatic alarm when radiation reaches high or dangerous levels; is built to AEC specs; unitized construction. Ranges can be tailored to application. In general, standard units cover any three consecutive ranges of gamma radiation between 0.01 mr/hr and 1,000,000 r/hr. Six-decade range available. Beta-gamma range is from 1 mr/hr to 1,000,000 r/hr.—*The Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, Ohio.*

For more information circle **308** on inquiry card.

DUPLEX RATEMETER

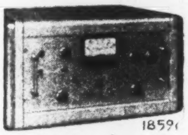
New Model 412 Dual Rate Meter is a unique log and linear multirange ratemeter whose extreme accuracy over a wide choice of linear ranges allows use for the first time of rate-measuring instrument in many operations now utilizing scalers. It will drive a recorder from both linear and log scales.—*Baird-Atomic, Inc., 33 University Rd., Cambridge 38, Mass.*



2211

For more information circle **309** on inquiry card.

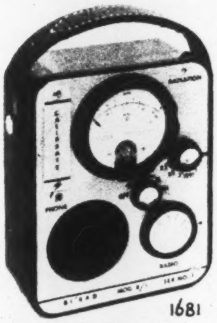
PULSE SPECTROMETER


1859

New Model C-2910 counts only those pulses lying within a selected channel or "window" defined by front panel controls; can provide from 750 to 2,000 v; regulation 0.01% of ac line voltage. Five ranges for both count-rate and integral modes of operation.—*NRD Instrument Co., 9842 Manchester, St. Louis 19, Mo.*

For more information circle **310** on inquiry card.

RADIATION DETECTOR AND RADIO RECEIVER


1681

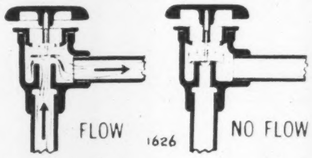
New Model P-1R combines a small lightweight gamma detector with a standard all-transistor radio receiver; is a result of suggestions from governmental agencies and civilian groups; features high sensitivity detection, background to 100 r/hr, logarithmic scales, self-contained ionization chamber, 1-year mercury battery supply.—*Riggs Nucleonics Co., 1699 East Mendocino Ave., Altadena, Calif.*

For more information circle **311** on inquiry card.

miscellaneous

VACUUM BREAKERS

New Type VB Series Anti-Siphon Vacuum Breakers prevent polluted water from siphoning back into potable supply line where supply enters an appliance or fixture below overflow rim.—*Cash-Acme, P. O. Box 191, Decatur, Ill.*



1626

For more information circle **312** on inquiry card.

VITAL FUNCTION MONITOR

New Vital Function Alarm continuously monitors iron lungs, rocking beds, etc., which go through a rhythmic cyclic sequence; can be easily adapted to patients with cardiac or respiratory difficulties. Alarm sounds and lamp flashes if normal cycle ceases momentarily, if there is a power failure, in event of short in pickup

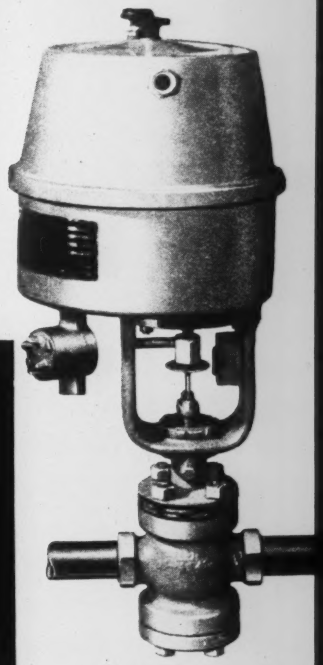
Circle **89** on inquiry card. →

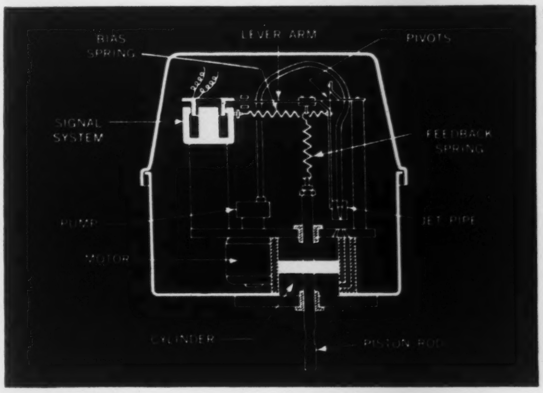
A faster, more accurate LOW-COST way to operate valves from an electrical signal

ASKANIA

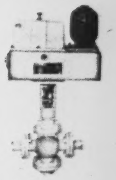
EHVA

ELECTRO-HYDRAULIC VALVE ACTUATOR



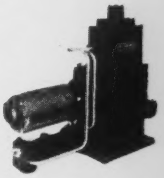


COMPLETELY SELF-CONTAINED



Above: Model RB-684 EHVA with a stall thrust of 1500 lbs., valve stem speed up to .9 i.p.s.

Below: Crank-type EHVA has stall torque of 4,000 in.-lbs.



For any sliding-stem control valve with ½" to 1½" stroke and requiring less than 235 lbs. thrust, the Askania Model RF-697 Electro-Hydraulic Valve Actuator uses the famed Askania Jet Pipe Principle to give all the advantages of hydraulic valve operation from a low-level AC or DC signal. Standard range is 1 to 5 ma. DC.

The compact housing, only about 13" in diameter, contains the entire operating mechanism—signal system, Jet Pipe relay, pump, motor, work cylinder, valve position feedback, and oil reservoir—even the rectifier for AC signals. There are no gears or complicated linkages. It mounts directly on sliding stem control valves; with simple adapters it can be applied to a butterfly or cock-type valve, or to other types of mechanisms. Hydraulic operation is fast, positive, and precise. And Askania gives hydraulic operation straight-line simplicity, for easy installation, low maintenance, and long service life.

Only Askania, with a world of experience in adapting hydraulic power and precision to automatic control problems, could bring you this improved, compact unit at such an unbelievably low price! Mail the coupon today for all the facts about Model RF-697 and other Askania Electro-Hydraulic Valve Actuators.

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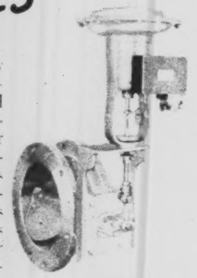
AUTOMATED FOR CONTROLLED FLOW

ROCKWELL

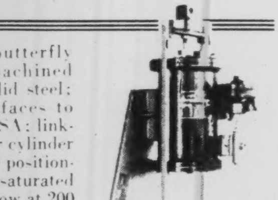
BUTTERFLY VALVES



Standard butterfly valve with simplified bracket and linkage to air diaphragm operator and valve disc positioner; provides maximum adjustment, minimizes friction, eliminates backlash, chatter and hunting, reduces power requirement in close control applications.

Standard heavy duty butterfly valve with Limitorque electric motor, declutching mechanism and handwheel for air, gases, water or other fluids.

Threaded butterfly valve with "Robot-air" diaphragm operator.



Wafer butterfly valve machined from solid steel; flange faces to 300# ASA; linked to air cylinder and disc positioner; for saturated steam flow at 200 psig.

Rockwell valves for gases, liquids or solids are furnished with any approved operators and control devices to provide automatic proximate or remote operation. Write for catalog.

W. S. ROCKWELL COMPANY
2128 ELIOT STREET
FAIRFIELD, CONN.

For more information circle **90** on inquiry card.

cable, if operator connects system to patient or machine and forgets to turn it on.—*Nelson Instrument Co., 607 Howard St., Evanston, Ill.*

For more information circle **313** on inquiry card.

PIPING TEMPLATE

New No. 43 is designed for isometric piping layout drawings; allows fast and accurate drawing in the three planes of a perspective view. Over-all size 8½" x 5½".—*Rapidesign, Inc., Box 429, Burbank, Calif.*

For more information circle **314** on inquiry card.

PLASTIC DEIONIZERS

New two-cell D-Ion Master Deionizers are available in seven sizes, rated at service flow rates of 5 to 120 gph. Each is shipped ready for ion-exchange and adsorption problems or to supply demineralized water. Transparent construction permits observations of resins during operation.—*Ion Exchange Products, Inc., 9349 S. Cottage Grove Ave., Chicago 19, Ill.*

For more information circle **315** on inquiry card.

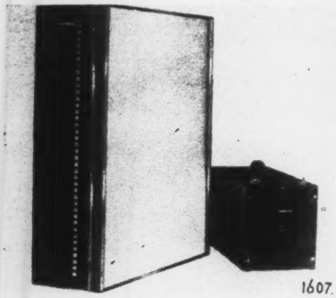
TELESCOPE

New Swiss Alpatir featherweight but shockproof scope, for shooting ranges, etc., as well as for astronomical use, has interchangeable eyepieces for magnifications of 28, 45 or 55 ×. Telephoto and other accessories.—*Karl Heitz, Inc., 480 Lexington Ave., New York 17, N. Y.*

For more information circle **316** on inquiry card.

LIGHT SOURCE

New Trans-Luminator for exposing printed circuits, for projection printing of negatives, etc., produces a cool, even, and highly actinic light (4500-A peak). In speed of exposure it is as fast as carbon arc lamp, or faster, but consumes only 1/10 of power. Sizes from 12 x 12" to 32 x 36".—*Aristo Grid Lamp Products, Inc., 65 Harbor Road, Port Washington, L. I., N. Y.*



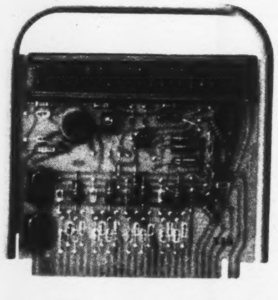
For more information circle **317** on inquiry card.

HIGH-SPEED, DYNAMIC DIGITAL MODULES

Build your high-speed computing and digital control equipment with COMPUTER CONTROL T-PACs, high-speed dynamic digital modules.

T-PACs

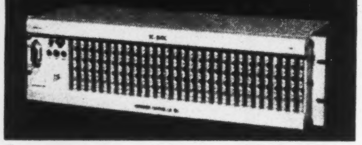
are a transistorized family of 1 megacycle dynamic logical circuits. Twenty-nine T-PACs, plus a transistorized plug-in power supply, mount in a standard 5¼ inch rack panel space. The basic LOGICAL ELEMENT T-PAC, model LE-10, can serve any one of a variety of functions, such as—amplifier, inverter, driver, buffer, flip-flop, counter stage, gate, frequency divider, half-adder, shift register stage . . .



Logical Element Model LE-10. . .

plugs into . . .

T-BLOC containing 29 T-PACs



Typical applications of T-PACs
- data handling
- control
- instrumentation
- computing systems

Write for illustrated 16-page Catalog T.

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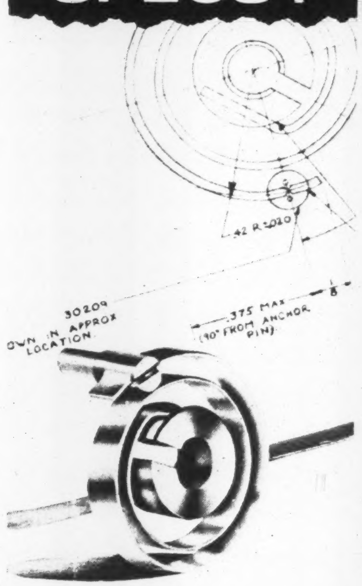
For more information circle **91** on inquiry card.

RIGID SPRING SPECS?



We're used to them here at John Chatillon & Sons. Specifications calling for incredibly close tolerances and little-known alloys are capably met by experienced hands and brains.

When the machinery you design calls for precision springs seemingly not available, consult with the Spring Engineers at John Chatillon & Sons. You'll save time, and get springs designed for your most exacting needs.

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Manufacturers of Precision Springs and Force Measuring Instruments Since 1835.

For more information circle 92 on inquiry card.

last-minute items

SELENIUM BATTERY CHARGER. New improved tubeless Selenicharger for heavy-duty applications, in sizes from 5 to 1,000 amp for batteries from 6 to 230 volts, is completely self-protected and completely automatic in operation.—American Rectifier Corp., 95 Lafayette St., New York 13, N. Y.
For more information circle **318** on inquiry card.

CABLE FAULT LOCATOR. New "Thumper" pinpoints defective insulation determined through high-potential testing of electric power cables, or faults developed in service. Precision is achieved regardless of length of cable.—Associated Research, Inc., 3777 W. Belmont Ave., Chicago 18, Ill.
For more information circle **319** on inquiry card.

SOLVENT. New Gyroclean Solvent 113, specially purified trichlorotrifluoroethane, fills need of makers of gyroscopes and other precision instruments; is said to have "the best combination of properties of the currently available solvents commonly used for such cleaning purposes."—Bacon Industries, Inc., 192 Pleasant St., Watertown 72, Mass.
For more information circle **320** on inquiry card.

VALVES FOR O.E.M. New series of 0-250 psi manual four-way air and oil valves are priced for original equipment manufacturers.—Barksdale Valves (Control Valve Div.), 5125 Alcoa Ave., Los Angeles 58, Calif.
For more information circle **321** on inquiry card.

INSTRUMENT MOTOR. New Type B subfractional-watt miniature dc instrument motor weighs about 2 oz; is of unique design: neither revolving windings nor sliding commutator contacts. Operates on about 12 ma @ 4½ to 6 vdc.—Brailsford & Co., Inc., 670 Milton Rd., Rye, N. Y.
For more information circle **322** on inquiry card.

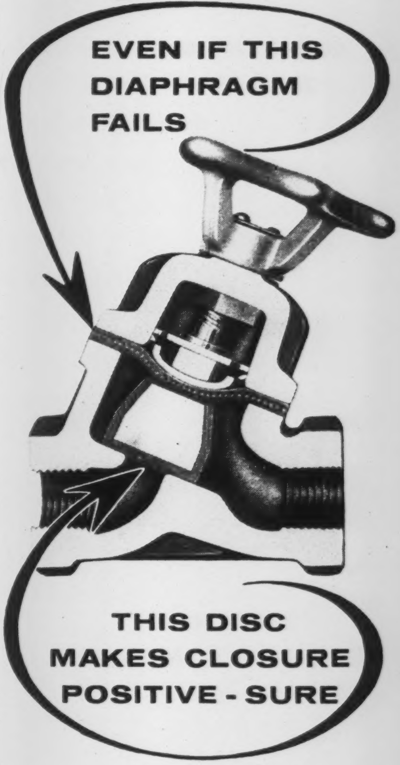
STEAM METER. New pressure-compensating counter box enables Shuntflo meter to register consumption accurately in pounds of steam even when major pressure fluctuations occur. Can be installed on Shuntflo meters now in service.—Builders-Providence, Inc., 345 Harris Ave., Providence 1, R. I.
For more information circle **323** on inquiry card.

INSTRUMENT FUSES, subminiature, hermetically-sealed in glass tubes with lead-ins for miniature circuits, etc. Two sizes: 0.140" x 0.300", 1/20 to ½ amp @ 125 v; ¼" x ⅝", 1 to 5 amp @ 32 v.—Bussman Mfg. Div., McGraw-Edison Co., University at Jefferson, St. Louis 7, Mo.
For more information circle **324** on inquiry card.

SUBMINIATURE SHIFT REGISTERS. New transistor-driven Type A-66, ⅛ cubic inch, operate from 0 to 95 kc; combine wide operating tolerances with low peak power.—C K Components, Watertown, Mass.
For more information circle **325** on inquiry card.

10-WATT RESISTOR. New RH-10 subminiature precision wire-wound

CLOSES TIGHT *regardless*


EVEN IF THIS DIAPHRAGM FAILS
THIS DISC MAKES CLOSURE POSITIVE - SURE

With Rockwell "D-D" Diaphragm Valves, you don't depend on the diaphragm to seal and shut-off fluid flow. This is done by the tight seating disc which will always close even should the diaphragm rupture in corrosive, abrasive, vacuum or other service.

The diaphragm serves a single purpose: to seal the valve's operating mechanism. It can be replaced without removing the valve from the line.

Rockwell "D-D" Valves provide other advantages: low closing torque; low pressure drop; high capacity; minimum maintenance. Available with lined and unlined bodies; flanged, threaded or with union ends. Get Bulletin 800.

You're SURE - You're SAFE with ROCKWELL "D-D" VALVES

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For more information circle 93 on inquiry card.

Photographer Bernard Hoffman found even the free flow of CO_2 from a cake of dry ice is difficult to control.

Controlling Flow in Fluid Engineering

To tame and control flow accurately, you must relate it to pressure, volume, turbulence and other variables. That's when you can look to the engineering leadership of S. Morgan Smith.

Butterfly valves are a good example. For the majority of processing situations, a wide range of standard R-S Butterfly Valves are assembled from stock for fast shipment. But for special fluid control problems, one or more can be applied to solve your needs. Standard or special, all R-S Butterfly Valves give you uniform flow control through all positions in the normal regulating range. You get minimum turbulence and pressure drop, save on pumping power because of simplified design and streamlined vanes. Compact and light in weight, they give you quick regulation and tight closure.

To learn more about the complete SMS line of Rotovalves, Ball and Butterfly Valves, call on our nearest representative. For information on special engineering, write S. Morgan Smith Co., York, Pa.

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For more information circle 94 on inquiry card.

power resistor is contained in a black anodized aluminum housing with radiating fins. Values from 0.5 to 30,000 ohms.—Dale Products, Inc., Columbus, Neb.

For more information circle **326** on inquiry card.

PUSH-PULL PLUGS. New DM9700 Series rugged miniature electrical push-pull plugs lock and unlock in direction of plug travel without lockwiring or twisting and without bayonet or coupling nut.—The Deutsch Co., 7000 Avalon Blvd., Los Angeles 3, Calif.

For more information circle **327** on inquiry card.

HOIST SAFETY. New open-throat hook Dyna-Switch stops crane or hoist overloading by cutting off power.—W. C. Dillon & Co., Inc., 14620 Keswick St., Van Nuys, Calif.

For more information circle **328** on inquiry card.

INSPECTION GLASS. New 3 D 3 Opticaid spectacle loupe magnifies 3 times at arm's length; has separate lenses for each eye; gives magnified vision in three dimensions.—Edroy Products Co., 480 Lexington Ave., New York, N. Y.

For more information circle **329** on inquiry card.

CONNECTOR KIT. New lab kits contain assortments of microminiature coaxial connectors; are available for 50, 75, and 95 ohm work; come in 6-drawer plastic cabinets.—Electro-Physics Labs, 2065 Huntington Dr., San Marino, Calif.

For more information circle **330** on inquiry card.

ELECTRONIC DATAPLOTTER. New 3033 B-LP accepts digital data presented to it in the form of punched cards or punched paper tape, and then records it graphically with an ink drawing on 30"x30" paper.—Electronic Associates, Long Branch, N. J.

For more information circle **331** on inquiry card.

FUSED QUARTZ, heretofore generally available only in standard cylindrical ingots, now can be forged into special shapes which enable quartz users to eliminate up to 95% of their wastage. —Engelhard Industries, Inc., Hillside, N. J.

For more information circle **332** on inquiry card.

MINIATURIZED SHIFT REGISTERS. New Minibits, with operating rates up to 500 kc and above, feature ⅛ cubic inch per binary digit.—Epsco Components, 108 Cummington St., Boston, Mass.

For more information circle **333** on inquiry card.

PHOTOELECTRIC CONTROLS. New subminiature (over-all length ⅞") are for use with company's IRC-5 control relay.—ESS Instrument Co., Dept. M, Bergenfield, N. Y.

For more information circle **334** on inquiry card.

CORROSION-RESISTANT THERMOSTATS. Two new stainless steel Thermoswitch units provide both resistance to corrosion and higher temperatures than previous designs.—Fenwal Inc., Ashland, Mass.

For more information circle **335** on inquiry card.

DUCTILE BISMUTH of high purity in strip, grid and film form for Gauss and Hall measurements; also in two alloys formed into wires for thermocouples.—Fitzpatrick Electric Supply Co., 444 Irwin St., Muskegon, Mich.

For more information circle **336** on inquiry card.

CEMENT SAMPLER KIT contains 14 different types of special cements, offers solutions to surface joining problems in research, development and production. Each bottle has its own applicator.—General Cement Mfg. Co., 400 S. Wyman St., Rockford, Ill.

For more information circle **337** on inquiry card.

MICROMINIATURE CAPACITORS. New slug-type microminiature Tantalytic capacitors are polar units that permit higher microfarad ratings than can be obtained by wire-type units of the same case size. Ratings from 1 to 20 vdc; 0.1 to 16 uf.—General Electric Co., Schenectady 5, N. Y.

For more information circle **338** on inquiry card.

COMPUTER GRADE CAPACITOR. New dc Alumalytic capacitors, designed specifically for circuits demanding highest reliability, are rated from 30,000 uf at 10 vdc to 1,000 uf at 450 vdc and will operate from −20°C to 65°C.—General Electric Co., Schenectady 5, N. Y.

For more information circle **339** on inquiry card.

MICROMINIATURE RELAY. New hermetically-sealed dp-dt dc Type GS has 0.2" spacing of its 8 terminals (2x4) to mate with new 0.1" spacing on printed circuit boards.—General Electric Co., Schenectady 5, N. Y.

For more information circle **340** on inquiry card.

SUB-FHP MOTOR. New RBD-25 variable-speed subfractional-hp dc motor is available in 0.5 oz-in and 1.0 oz-in models, both 115 vdc, 1800 rpm.—Holtzer-Cabot Motor Div., 125 Amory St., Boston 19, Mass.

For more information circle **341** on inquiry card.

GRINDING SPINDLE. New Swedish UVA Turbo-Head, 60,000 to 100,000 rpm, infinitely variable. Various collets and quills available.—Homestrand Inc., 9 Addison St., Larchmont, N. Y.

For more information circle **342** on inquiry card.

SILICON DIODES. New miniature all-welded silicon power diodes are specifically designed for missile and airborne equipment applications.—International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif.

For more information circle **343** on inquiry card.

MULTICONDUCTOR CABLE. New flat Polystrip, available in widths up to 51 conductors, is 80% lighter in weight and saves preparation and assembly time by approximately 90% over a conventional cable.—International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa.

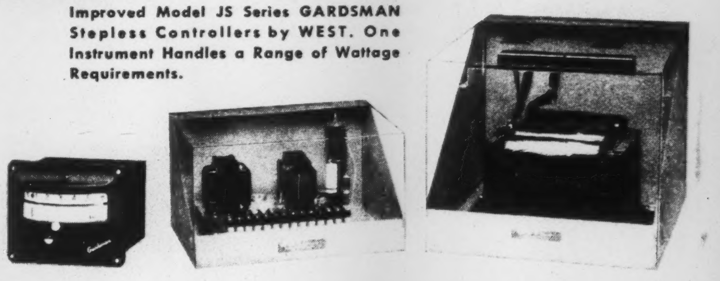
For more information circle **344** on inquiry card.

SUBCARRIER OSCILLATOR. New Model MSO 1, for use with thermocouples and other low-output primary elements, achieves a ±7½% deviation

Stepless temperature Control

NOW! TUBELESS, MULTI-LOAD

Improved Model JS Series GARDSMAN Stepless Controllers by WEST. One Instrument Handles a Range of Wattage Requirements.



- ★ Closest Control
- ★ Save power
- ★ Prolong Heater Life
- ★ Adjustable Band
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- ★ Simplest Operation—One Knob
- ★ Least Maintenance

Without tubes or relays, this unique instrument *modulates* input to suit demand. Proved in wide use. Write for Bulletin JS.

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WEST *Instrument* CORPORATION
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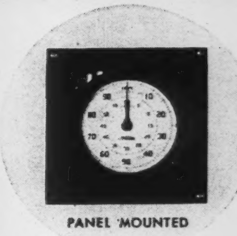
For more information circle **95** on inquiry card.

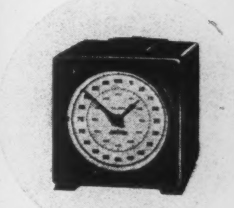
precision timers by... STANDARD TRADEMARK

Industry's preferred "instrument of a thousand uses". Accurate, rugged, versatile STANDARD Elapsed Time Indicators. Synchronous motor drive. Electric clutch controlled by manual or automatic switch or output of electronic tubes. Manual or electric zero reset. Units for flush panel mounting or portable use.



PANEL MOUNTED

Model	Scale Divisions	Totalizes	Accuracy
S-100	1/5 sec.	6000 sec.	±.1 sec.
S-60	1/5 sec.	60 min.	±.1 sec.
SM-60	1/100 min.	60 min.	±.002 min.
S-10	1/10 sec.	1000 sec.	±.02 sec.
S-6	1/1000 min.	10 min.	±.0002 min.
S-1	1/100 sec.	60 sec.	±.01 sec.
MST	1/1000 sec.	.360 sec.	±.001 sec.
MST-500	1/1000 sec.	30 sec.	±.002 sec.



PORTABLE

Request Bulletin No. 198.

THE STANDARD ELECTRIC TIME COMPANY
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For more information circle **96** on inquiry card.

New COX
Flow Indicator

2% Accuracy

SPAN
SPECIFIC GRAVITY
ON
POWER

Type 7A

The Cox Flow Indicator provides a dramatic new dimension in direct reading instrumentation. Where accuracy and reliability are essential *at a low initial cost*, the Type 7 is the answer.

The Indicator is for use with Cox turbine flowmeters or other transducers producing a frequency signal directly proportional to flow rate. It is available for readout in either volumetric or gravimetric units—with specific gravity adjustment. A span adjustment enables the Indicator to be calibrated to any particular transducer. Panel and portable models are available.

A second model not shown, the Type 7B, provides accuracy of 1% of flow.

We welcome the opportunity to demonstrate the Type 7 Indicator to you, without cost or obligation, to prove its superior features. *Cox Instruments Division, George L. Nankervis Company, 15200 Fullerton Avenue, Detroit 27, Michigan.*

A new bulletin describing the Type 7 Indicator is available. Ask for Bulletin No. 700

Cox Instruments

Precision Instruments Since 1912

For more information circle **97** on inquiry card.

from a ±5 mv (<1 microwatt) input signal and also features good stability and high-output with low distortion. Available in standard RDB bands; packaged for airborne use.—Invar Electronics Co., 1749 N. Eastern Ave., Los Angeles 32, Calif.

For more information circle **345** on inquiry card.

SAFETY VALVE. New No. 10 Safety Shutt-off Valve, originally developed for gasoline pump use, closes automatically in case of fire or accidental bumping. 1", 1¼", ,and 2" sizes.—Jordan Industrial Sales Div., 6013 Wiehe Rd., Cincinnati 13, Ohio.

For more information circle **346** on inquiry card.

SCINTILLATION CRYSTALS. Thallium-activated sodium-iodide crystals, grown in ingots 5" D x 4" L plus a 90° conical end, can be supplied in any sizes and configurations derivable from this shape.—Levinthal Electronic Products, Inc., Nuclear Div., Stanford Industrial Park, Palo Alto, Calif.

For more information circle **347** on inquiry card.

RECORDING AND PLAYBACK HEAD. New Model 305 7-channel mag tape head, designed for 1" tape for standard use, is adaptable to 14 channels by interlacing.—Lipps Engineering, 1511 Colorado Ave., Santa Monica, Calif.

For more information circle **348** on inquiry card.

EXPANDED-SCALE VOLTMETERS. Example, scale of a voltmeter used to measure values around 28 v covers 26 to 30 v (0 to 26 eliminated). Available in practically all sizes, shapes and ranges, with pointer deflections from 90° to 300°.—Miller Instrument Co., Inc., 165 E. Lincoln St., Encondido, Calif.

For more information circle **349** on inquiry card.

RANGE MARKER GENERATOR facilitates calibrating radars and other time-based equipment by producing three separately indentifiable sets of time marks.—Missouri Research Labs, 2109 Locust St., St. Louis, Mo.

For more information circle **350** on inquiry card.

GAGE BLOCKS. Simplex set of 7 blocks: 1/16", ⅛", ¼", ½", 1", 2" and 3", and hardwood case. Guaranteed accuracy 6 microinches.—Opto-Metric Tools, Inc., 137 Varick St., New York 13, N. Y.

For more information circle **351** on inquiry card.

STATIC INVERTER. Completely transistorized Model M-977 supplies dc and ac power in target drones, operates from a 28-29-vdc input to deliver outputs of 150 vdc @ 140 ma, 6.5 vac (400 cps) @ 2.1 amp, and —22½ vdc @ 50 ua.—Perkin Engineering Corp., El Segundo, Calif.

For more information circle **352** on inquiry card.

TEMPLATE. New No. 58 large hexagon screw heads template contains cutouts for hexagons from ⅛" to 2" and corresponding chamfer circles and symbols for side elevation of crown.—Rapidesign, Inc., P. O. Box 429, Burbank, Calif.

For more information circle **353** on inquiry card.

BLOW TORCH. New Model RV-2000 provides a wide range of flame shapes from needle point to a wide brush.—Research Vacuum Supply Co., 6712 N. Clark St., Chicago 26, Ill.
For more information circle **354** on inquiry card.

CHOPPER. New Model 50 transistorized electronic chopper or modulator is non-mechanical, inertialess, temperature-stable; has wide dynamic range extending down to a fraction of a millivolt.—Solid State Electronics Co., 8158 Orion Ave., Van Nuys. Calif.
For more information circle **355** on inquiry card.

CONVERTER. New Model D-400 transistorized powerpack converts 24 to 30 vdc to a stable 400-cps with an output of 10 watts. Other models provide for various dc input voltages between 19 and 100.—Standard Electric Time Co., 89 Logan St., Springfield, Mass.
For more information circle **356** on inquiry card.

DC BRAKE. New shunt wound d c model of the Style HT70 Series offers torque ratings from 10 lb-ft through 105 lb-ft. Standard and waterproof enclosures available.—Stearns Electric Corp., 120 N. Broadway, Milwaukee 2, Wis.
For more information circle **357** on inquiry card.

TELEMETERING TRANSMITTER. New crystal-controlled Model 1474 for guided missiles, phase modulated 4 to 6 watts; stability 0.005% of center frequency. Will withstand 125° C and 100-G vibration and shocks.—Telechrome Mfg. Corp., 28 Ranick Drive, Amityville, L. I., N. Y.
For more information circle **358** on inquiry card.

SOLID TANTALUM CAPACITORS. New tan-TI-cap electrolytics, for use in miniaturized circuitry, reliability and temperature stability are vital factors, are immediately available in 18 ratings.—Texas Instruments, P. O. Box 312, Dallas, Texas.
For more information circle **359** on inquiry card.

TRANSFORMERS. New low-cost high-efficiency power transformers for use with 12 to 14 vdc transistor power supplies deliver from 250 to 600 vdc and provide 80% to 85% efficiency for entire supply.—Triad Transformer Corp., 4055 Redwood Ave., Venice, Calif.
For more information circle **360** on inquiry card.

CONSTANT-CURRENT SUPPLIES. New Model CCS-1/1000 has load current range of 1 ma to 1 amp with 13 vdc max across load. New CCS-.1/5 has a load current range from 100 ua to 5 ma with the same maximum voltage across load.—Ultradyne Inc., P. O. Box 3308, Albuquerque, N. M.
For more information circle **361** on inquiry card.

VDR WITH DIAL. New APD1/2 Dialpot subminiature voltage dividing resistor suitable for printed circuits, has a dial graduated radially for side reading and on end for end reading. Resistance range is 0.5 ohm to 0.25 megohm. Wattage dissipation 1 watt at 40°C.—Waters Mfg., Inc., Boston Post Rd., Wayland, Mass.
For more information circle **362** on inquiry card.

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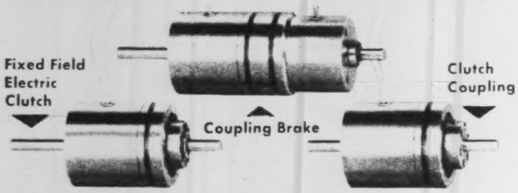

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Three styles of Simplatrol Fixed Field Clutches ranging from 7/8" to 3 1/8" diameter. Torque output ranges from 10 oz. inches to 100 lb. inches.

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new plants and mergers

GENERAL ELECTRIC CO. will construct a permanent plant for its Computer Dept. near Phoenix, Arizona.

DREXELBROOK CONSULTING SERVICE, a new firm, has been set up at Abington, Penna. for consulting in the instrument, automation and control fields. The owner is Fred Maltby, well-known instrument specialist.

E. C. SMITH MFG. CO. has relocated in larger headquarters at Conshohocken, Penna.

AMERICAN OPTICAL CO. has added the line of PATWIN analytical instruments to its line of scientific instruments.

NATIONAL TANK CO. oil field equipment will be implemented by acquiring **INSTRUMENTS, INC.**, manufacturers of electrical controls and automatic equipment.

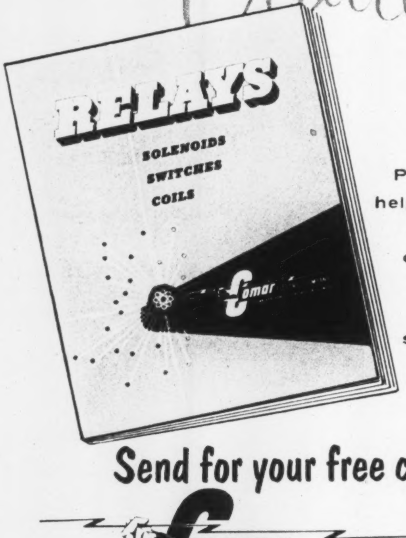
GENISCO, INC. has formed a new subsidiary, **GENISTRON, INC.**, to design and manufacture precision electronic filters used in missile and aircraft applications.

MIDWESTERN INSTRUMENTS has purchased a third company, Modern Art Metal Finishing Co., as part of a major plan for adding essential elements to facilities over which it will exercise complete quality control.

DRESSER INDUSTRIES' European affiliate, **DRESSER A. G.**, announces expansion of its **SIE (SOUTHWESTERN INDUSTRIAL ELECTRONICS) DIV.**

BENDIX AVIATION CORP., Pacific Div., has opened an analog computing facility in the Systems Analysis Branch.

NEW Catalog



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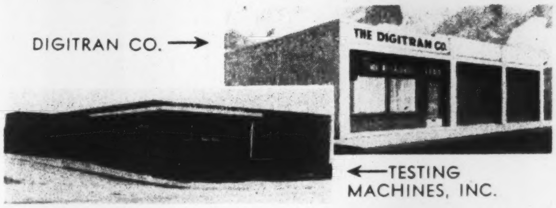


TESTING MACHINES, INC. has moved into enlarged facilities and offices at Mineola, L. I.

DIGITRAN CO., formerly known as the **ANATRAN DIV. of ENDEVCO CORP.**, has moved into new headquarters in Pasadena, Calif.

HIGH VOLTAGE ENGINEERING CORP. has acquired controlling interest in **ELECTRONIZED CHEMICALS CORP.**

ENGINEERED ELECTRONICS CO. will represent **AD. AURIEMA, INC.**, major export organization in electronics, on a world wide basis, exclusive of the U. S., its possessions and Canada.

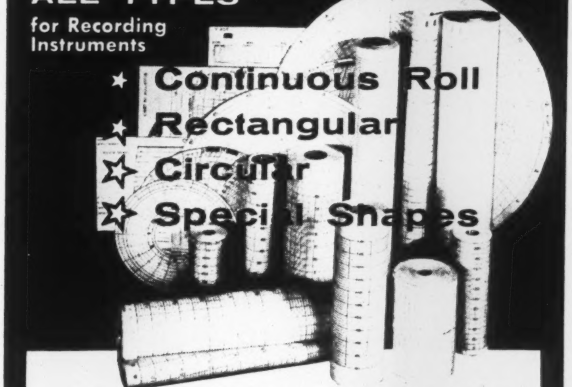
RAMO-WOOLDRIDGE CORP. and **THOMPSON PRODUCTS, INC.** jointly announce formation of a new subsidiary corporation, **THOMPSON-RAMO-WOOLDRIDGE PRODUCTS, INC.**

RADIATION INSTRUMENT DEVELOPMENT LAB., INC. is again expanding its facilities to enable greater production of nucleonic equipment.

ORRADIO, affiliate of **AMPEX CORP.**, has placed its new half-million dollar magnetic-tape plant into operation.

VAPOR RECOVERY SYSTEMS COMPANY has completed its plant-wide expansion program at Compton, Calif.

GUBELMAN CHARTS
ALL TYPES
for Recording Instruments



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This personnel monitoring instrument measures the cumulative exposure to gamma or x-rays over a given period of time. The instrument consists of an ionization chamber, a quartz fibre electrometer and a graduated scale and viewing system.

The charging unit comprises a 180 volt "B" battery, a 1½ volt "A" battery, a flashlight bulb, the well for inserting Dosimeter, and the charging control.

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DIAPHRAGM GAUGE
FOR ACCURATE PRESSURE MEASUREMENT IN OUNCES OR INCHES OF WATER

Marshalltown Figure 83 is an extremely sensitive gauge that uses a carefully seasoned bronze diaphragm to accurately measure very low pressures. It is used extensively on many types of natural gas installations for checking low pressures.

Available in standard dials (reading in inches of water) 0-15" -0-30" -0-60" -0-100" -0-160" . . . also in ounce graduated dials from 15 ounces to 5 pounds. 2½", 3½" and 4½" dial sizes mounted in black enameled steel case.

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Eleven types, both single and double pole.

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ALL TYPES KNOWN GLASS

*Carried in stock
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For more information circle **105** on inquiry card.

people in the news

W. S. CHRISTIAN

N. S. BASSETT

J. R. WHITESIDE

BARTON INSTRUMENT CORP. has appointed *Claude B. Nolte* vice president in charge of Product Engineering and Development; *Everette M. Furr*, factory superintendent; and *William S. Christian*, sales manager.

MINNEAPOLIS-HONEYWELL has appointed *N. S. Bassett* sales manager of the Davies Laboratories Div.

SIMPSON ELECTRIC CO. has named *J. R. Whiteside* president.

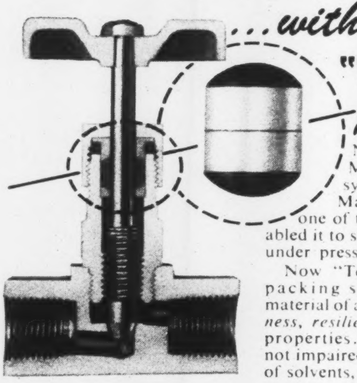
PERKIN-ELMER CORP. has elected *Theodore F. Talmage* to the Board of Directors.

VARIAN ASSOCIATES has named *Curtis E. Ward* manager of Small Tube Product Development.

TEXAS INSTRUMENTS has elected *Dr. Lloyd V. Berkner* to the Board of Directors.

MASON-NEILAN Div. of Worthington Corp. announces appointment of *James M. McAlear* as manager of the newly created Instrument Sales Div.

NASH ENGINEERING CO. has appointed *Edward A. Barton* manager of the Cleveland Office.



"...yet we have IMPROVED it"

The Marsh Stainless Steel Needle Valve could have gone right on being the finest in its field ... yet we have improved it

...with fabulous "TEFLON" packing

Note the "close-up." The Marsh Marpak packing system, originated in the Marsh Needle Valve, was one of the factors that has enabled it to stand up and work right under pressures up to 10,000 psi.

Now "Teflon" is used in this packing system—the miracle material of almost incredible *toughness, resilience* and *non-adhesive* properties... properties that are not impaired by the most powerful of solvents, acids, or alkalies even at temperatures *up to 500° F.*

Net result: The guaranteed application-range (up to 10,000 psi) is now effective at any temperature up to 500° F. (In other makes, permissible temperature decreases as pressure increases.)

Marsh Marpak Teflon Packing System is standard in Marsh 416 Stainless Steel Needle Throttling Valves. Ask for facts.

MARSH

Needle Valve in 416

stainless steel throughout
Now with "Teflon" Packing

MARSH INSTRUMENT CO. *Sales Affiliate of Jas. P. Marsh Corp.*, **Dept. 42, Skokie, Ill.**
Marsh Instrument and Valve Co. (Canada) Ltd., 8407 103rd St., Edmonton, Alberta
Houston Branch Plant: 1121 Rothwell St., Sect. 15, Houston, Texas

For more information circle **106** on inquiry card.

E. BRAUN

A. L. MUNZIG

R. R. LENT

WATERMAN ENGINEERING CO. has named *Edward Braun* manager, Industrial Div. and *Harry A. Hedland* manager, Aviation Div.

LIBRASCOPE, INC., a subsidiary of General Precision Equipment Corp. has appoined *Arthur L. Munzig, Jr.* sales manager for the Commercial Division.

STATHAM INSTRUMENTS, INC. has appointed *Robert R. Lent* director of sales.

MANNING, MAXWELL & MOORE has appointed three new district sales managers: *Robert L. Logan*, Tulsa; *Lamar F. Kirby*, Atlanta; *Arthur H. Barnes*, Los Angeles.

THE FOXBORO CO. has appointed *E. R. Huckman* assistant field sales manager.

BAILEY METER CO. has named *H. D. Vollmer, Jr.* manager of the newly created Atomic and Marine Div.

NEFF INSTRUMENT CORP. has named *Richard A. Shaw* chief engineer.

STROMBERG-CARLSON has appointed *Martin T. Zegel* product planning manager of the Special Products Div., and *William E. Cutler* sales manager, Commercial Products.

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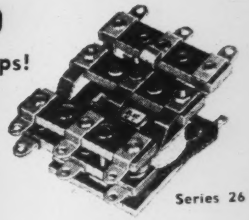

Series 26

FEATURES:

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- Fast acting—5 milliseconds at 3 watts
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- Standard or special mounting bases available
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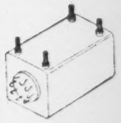

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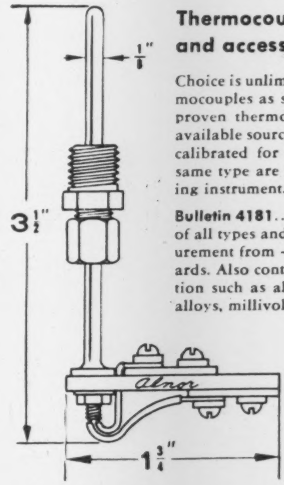

Thermocouples, alloy wire, and accessories

Choice is unlimited at Alnor, where you'll find thermocouples as small as 1/8" O.D. and more unique, proven thermocouple designs than at any other available source. Each thermocouple is individually calibrated for its specific application—all of the same type are interchangeable without recalibrating instrument.

Bulletin 4181... lists thermocouples and accessories of all types and alloys for every temperature measurement from —100° F. to 3000° F., to ISA Standards. Also contains complete engineering information such as alloy curves, uses and limitations of alloys, millivolt relationship tables, etc.

Bulletin 4257... lists *surface* temperature thermocouples and accessories available from Alnor.

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Model 3480 small pipeline thermocouple. Precision built to Alnor performance standards. Unit price: $9.00.

PRECISION INSTRUMENTS FOR EVERY INDUSTRY

Alnor

For more information circle **109** on inquiry card.

new literature

AUTOMATION

METERING AND CONTROL systems. 4-page Bulletin 500 describes purpose, design, and operation of maker's systems; includes a discussion of pneumatic and electric telemetering, and pneumatic control, also literature references for all products making up these systems.—Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.

Circle **401** on inquiry card.

FILTER-OPERATING CONTROL DESK is described in 2-page Product Specification G71-8.—Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.

Circle **402** on inquiry card.

CONTROL SYSTEM. 4-page Data Sheet ND46-33 (107), 2-page Prel. Data Sheet NU9 (3), and 4-page Insert Folder ND4 (7a) describe the new C.A.T. control system for use with magnetic amplifiers and saturable core reactors.—Leeds & Northrup Co., 4934 Stenton Ave., Phila. 44, Pa.

Circle **403** on inquiry card.

SOOT-BLOWING CONTROL. 16-page Bulletin 1029 describes Vulcan Selective-Sequence and Vulcan Automatic-Sequential insert-type panel automatic controllers; includes dimensions and equipment specifications for each model; lists typical installations.—Copes-Vulcan Div., Blaw-Knox Co., Erie 4, Penna.

Circle **404** on inquiry card.

TIME-IMPULSE TELEMETERING. 8-page Bulletin 230-P4 describes how Chronoflo Telemeters enable users to observe and record the operation of widely scattered meters at a central location from any distance.—Builders-Providence, Inc., 345 Harris Ave., Providence 1, R. I.

Circle **405** on inquiry card.

INSTRUMENT PANELS. 6-page folder titled "Panel Discussion" reviews fabrication of a flexible series of instrument mounting structures: panels, racks, cabinets, consoles, cubicles, graphic panelboards.—Falstrom Co., 154 Falstrom Court, Passaic, N. J.

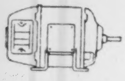
Circle **406** on inquiry card.

PHOTOELECTRIC CONTROLS. 24-page Catalog 58 describes many types of photoelectric controls; timing controls; light sources; phototube and light-source heads; electronic timers; etc.—Autotron, Inc., Box 722 CC, Danville, Ill.

Circle **407** on inquiry card.

HYDRAULIC GOVERNOR. 4-page Bulletin FP-217 describes Type 4300 compact light-weight Hydraulic Governor for control of gasoline or diesel engines, etc.—Farris Pickering Governor Co., Inc., Palisades Park, N. J.

Circle **408** on inquiry card.



MOTORS, SERVOS

PRECISION SYNCHROS. 8-page catalog and four 2-page data sheets describe and give specifications of synchro control transformers, transmitters, repeaters, resolvers, differentials, etc.—Kearfott Co. Inc., 1378 Main Ave., Clifton, N. J.

Circle **409** on inquiry card.

SOLENOIDS, SELECTORS, STEPPING MOTORS. 4-page Bulletin 1157LS covers maker's line of Ledex rotary solenoids, selector switches, hermetically sealed selectors, and syncramental stepping motors.—G. H. Leland, Inc., 123 Webster St., Dayton 3, Ohio.

Circle **410** on inquiry card.

SERVOMOTORS. 4-page Data Sheet 1286 presents information on new Model 18 SM 490 designed for continuous duty at 200° C total unit operating temperature; low rotor inertia and high stall torque.—2-page Data Sheet 912 gives details of new adjustable size 11 velocity-damped servomotor.—Beckman Helipot Corp., Newport Beach, Calif.

Circle **411** on inquiry card.

VALVES, ACTUATORS

ELECTROHYDRAULIC PILOT VALVE. 6-page Bulletin MSP-149 and Specification Sheet GH-300 cover new high-capacity servo valves.—Hagan Chemicals & Controls, Inc., Hagan Building, Pittsburgh 30, Pa.

Circle **412** on inquiry card.

CHECK VALVES. 4-page Bulletin 8K describes company's basic Swing Check Valve and modifications which include check valves with oil or air-operated cylinder; Hold-Open Swing Disc Valves with direct-connected cylinder; and check valves with threaded spindle for tight manual closing.—Dept. V-D, Schutte and Koerting Co., Cornwells Hghts., Bucks County, Penna.

Circle **413** on inquiry card.

VALVES. 2-page Bulletin J-90 describes new packless self-closing sliding-gate sampling valve for sampling hazardous and corrosive liquids.—4-page Bulletin F-29 describes new No. 10 Underwriters Labs—listed safety shut-off valve for multiple pedestals of remote pumping system.—Jordan Corp., 6013 Wiehe Rd., Cincinnati 13, Ohio.

Circle **414** on inquiry card.

CONTROL VALVES. 52-page Catalog 1500-C contains a wealth of information not only on maker's own valves, actuators and accessories but broadly-useful handbook-type information.—The Annin Co., 6570 Telegraph Rd., Los Angeles 22, Calif.

Circle **415** on inquiry card.

ELECTRIC ACTUATORS. 8-page Catalog T-83 describes Tork-Master Electric Valve Operators which can be field-mounted without removal of valves.—General Controls, 801 Allen Ave., Glendale 1, Calif.

Circle **416** on inquiry card.

VALVES for coke quenching are described in a 4-page Technical Bulletin W-15 which includes installation arrangements, parts lists, and dimensions.—4-page Bulletin W-11 describes rubber-lined cushioned swing check valves for use in pulp and paper, and in chemical industries.—Golden-Anderson Valve Specialty Co., 1285 Ridge Ave., Pittsburgh 33, Pa.

Circle **417** on inquiry card.

AMMONIA VALVES and accessories for refrigeration and industrial application are covered in 12-page Catalog No. 202.—Henry Valve Co., 3215 North Ave., Melrose Pk., Ill.

Circle **418** on inquiry card.

GLOBE VALVES and data. 20-page Section B-2 covers globe valves having 600, 1500, and 2500 lb ASA ratings; all of stainless steel, Monel or other corrosion-resisting materials; contains pressure, velocity and discharge conversion tables and other general engineering data.—Associated Valve & Engineering Co., 1150 W. Marquette Rd., Chicago 21, Ill.

Circle **419** on inquiry card.

TEMPERATURE

PORTABLE PYROMETER Indicator, "MiniMite" a null-balance potentiometer type, with ¼% accuracy is described in new 6-page Bulletin 64.—Thermo Electric Co., Inc., Saddle Brook, N. J.

Circle **420** on inquiry card.

THERMOMETERS. 4-page brochure describes indicating and recording thermometers available in a wide choice of bulb forms and materials, capillary lengths, ranges, mountings, etc.—The Partlow Corp., New Hartford (Utica), N. Y.

Circle **421** on inquiry card.

THERMOMETERS. Hydrometers, Pressure Gages, etc. 1958 binder contains five catalogs: (1) 24-page Catalog 125A covers industrial thermometers; (2) 8-page Catalog 425A covers general-purpose thermometers; (3) 36-page Catalog 325A covers dial-indicating and recording thermometers; (4) 16-page Catalog 225A covers engraved-stem thermometers, hydrometers and accessories; (5) 32-page Catalog 525A covers dial-indicating and recording pressure and vacuum gages, needle valves, cocks, and accessories.—Weksler Instruments Corp., 195 East Merrick Rd., Freeport, L. I., N. Y.

Circle **422** on inquiry card.

PYROMETERS. 8-page Catalog No. 175 includes descriptive and technical data on PYRO Optical, Micro-Optical, Radiation, Immersion, Surface and Indicating Pyrometers.—The Pyrometer Instrument Co., Inc., Bergenfield 4, N. J.

Circle **423** on inquiry card.

THERMOCOUPLES AND ASSEMBLIES. 8-page Bulletin GB-8 describes CeramiKouples, assemblies and components for heavy-duty industrial and research applications, with unique combinations of desirable properties.—E. C. Smith Mfg. Co., Forrest and Hector, Conshohocken, Penna.

Circle **424** on inquiry card.

PYROMETER SUPPLIES. 56-page Catalog G100-8 describes Honeywell's complete line of thermocouple accessories for measuring temperature; includes new Meg-O-Pak assemblies and new insulated extension wire.—Minneapolis-Honeywell Regulator Co., Wayne & Windrim Aves., Phila. 44, Pa.

Circle **425** on inquiry card.

FLOW, LEVEL, PUMPS

FLOW-RATE INSTRUMENTS. Several new-product bulletins for insertion in Catalog include Bulletin 165 on Flow-rate Alarms, Bulletin 250 on Brook-seals, also data sheets for prospective users' convenience.—Brooks Rotameter Co., Lansdale, Penna.

Circle **426** on inquiry card.

HYDROLOGICAL INSTRUMENTS. 20-page Bulletin No. 700 covers water level recorders, hook gages, rain gages and wind instruments; contains cross-sectional drawings of current meter and directions for adjustments of current meter pivot.—W. & L. E. Gurley, Hydrological Instruments Div., 514 Fulton St., Troy, N. Y.

Circle **427** on inquiry card.

LIQUID LEVEL CONTROLS. 8-page Form No. 25 describes Series T electrode-type floatless models operating on ac for use in conductive liquids including ordinary water.—Charles F. Warrick Co., 1964 W. Eleven Mile Rd., Berkley, Mich.

Circle **428** on inquiry card.

PUMPS FOR LIQUIDS. slurries or gases. 8-page brochure with 2-page price lists describes Sigmamotor Pumps comprising a flexible tube against which a series of fingers press in sequence to impart a positive unidirectional movement to the fluid in the tube.—Sigmamotor, Inc., 3 No. Main St., Middleport, N. Y.

Circle **429** on inquiry card.

PUMPS for abrasive slurries, gases, etc. 8-page Catalog 10.0 describes Flex-i-liner pumps featuring an eccentrically-mounted rotor which creates a progressive squeegee action on the fluid trapped between the outer surface of the flexible liner and the inner surface of the body block.—Vanton Pump & Equipment Corp., 201 Sweetland Ave., Hillside, N. J.

Circle **430** on inquiry card.

LIQUID FLOWMETER INSTRUMENTS. 8-page secondary instruments and accessories for changing Propeloflo Meter from a basically totalizing unit to one suitable for any combination of remote totalizing, indicating, and recording functions or for batch measurement.—Builders-Providence, Inc., 345 Harris Ave., Providence 1, R. I.

Circle **431** on inquiry card.

VENTURI TUBES. 32-page Technical Bulletin 110-P1 describes the various types of venturi tubes, their recovery characteristics, the formulae that determine their design, typical calculations, etc.—Builders Providence, Inc., 345 Harris Ave., Providence 1, R. I.

Circle **432** on inquiry card.

PRECISION

defined by the dictionary

. . . "the quality or state of being precise; accuracy; mechanical exactness."

defined by an instrument maker . . .

Swiss American

JEWEL BEARINGS

Sapphire and Ruby Precision Jewel Bearings

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- exact tolerances
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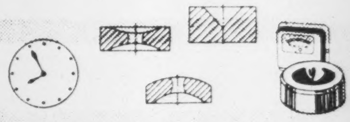

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Mass Produced For Industrial Requirements.

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32-30 58th St., Woodside 2, Long Island, N. Y.
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For more information circle 110 on inquiry card.

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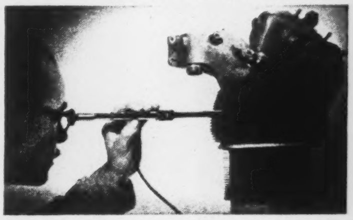
For Visual Inspection of Inaccessible Surfaces



Provides "inner eye" for inspection of combustion and compression engines, for oil and gas tanks, for hollow castings or bearings, for all internal surfaces which are dark and allow access only through a hole as small as ½". Used by leading aircraft and industrial companies.

Built-in illumination. Contains 12 highly corrected, achromatized, fluoride-coated lenses. Magnification varies with distance—from 2x at 12" to 6.25x at 3".

Two standard models: B20—½" dia. x 20" long and B29—½" dia. x 29" long. Write today for Technical Bulletin #8500.

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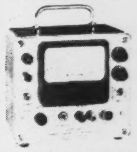
MANUFACTURING COMPANY
10122 E. Rush St., El Monte, California

For more information circle 111 on inquiry card.

NORTHAM

PORTABLE 3KC CARRIER SYSTEM



PORTABLE 3KC CARRIER SYSTEM MODEL PCS-1

8 inches wide — 6 inches deep
7 inches high — Weight: 10 lbs.

Model PCS-1 is a single channel portable 3 kc carrier system designed for use with variable reluctance transducers: specifically, Northam absolute, differential and gage pressure pickups and accelerometers.

Specifications of Model PCS-1 call for a regulated excitation voltage output from the oscillator of 10 volts rms at 3 kc and a demodulator output current linearity of better than 1% full scale, providing 1.0 ma into 50 ohms. An auxiliary filter (Model F-1) provides a suitable output for oscilloscopes, oscillographs, strip chart and pen recorders. A signal is produced flat within plus or minus three percent from 0 to 250 cps. There is also an output jack to permit operation of a remote meter as another alternative read-out.

Write for Bulletin. Northam Engineering facilities are available to assist you in any application problems.

NORTHAM ELECTRONICS, INC.
2420 N. Lake Ave., Altadena, Calif.

For more information circle 112 on inquiry card.

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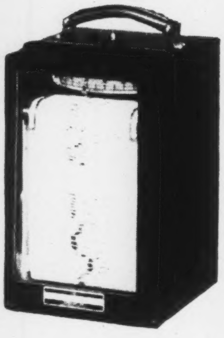

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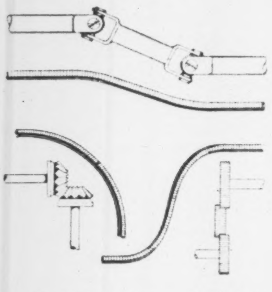
For more information circle 114 on inquiry card.

FLEXIBLE SHAFTING REDUCES GEARING



Flexible Shafting reduces the noisy and cumbrous gearing used in conjunction with solid shafts. It has the ability to transfer power from remote places, over, under, and around obstacles found in the path of installation between the drive and the driven units. Flexible Shafting requires very few parts, making them inexpensive; whereas solid shafts using universal joints, miter gears, and gear trains, many times would not be feasible because of their noisiness or lack of economy. With a Flexible Shaft assembly, design may be simplified and your engineering time spent on other necessary component parts without having to worry that they will create obstacles when placed where you want them.

Flexible Shafting cuts down on vibration thus offering long life with very little maintenance required. For complete Flexible Shaft information, write F. W. Stewart Corporation, 4311 Ravenswood Ave., Chicago 13, Illinois.

For more information circle 115 on inquiry card.

NEW LITERATURE

DIAPHRAGM PUMP for corrosive fluids. 4-page Sup. Bulletin 1225-2 describes Model 47 Chem-O-Feeder heavy-duty all purpose positive-displacement diaphragm for safe and dependable feeding of corrosive fluids. —Proportioneers, Inc., 345 Harris Ave., Providence 1, R. I.

Circle 433 on inquiry card.

PRESSURE, WEIGHT, ACCELERATION

PNEUMATIC INSTRUMENTS. 16-page Catalog 510 covers pneumatic pressure and temperature transmitters, receivers, indicators, pilot controllers, recording controllers and accessories. —United States Gauge Div. of American Machine and Metals, Inc., Sellersville, Penna.

Circle 434 on inquiry card.

MECHANICAL LOAD MEASUREMENT. 4-page Data Sheet ND 46-20 (1) presents data on electronic Speedomax G indicators and recorders for precise measurement of pressure, force, tension and weight using load-cells. —Leeds & Northrup Co., 4934 Stenton Ave., Phila. 44, Pa.

Circle 435 on inquiry card.

PRECISION PRESSURE GAGES. 4-page brochure describes a new automatic thermal compensation bar in linkage, which minimizes common sources of error.—Heise Bourdon Tube Co., Inc., Brook Rd., Newtown, Conn.

Circle 436 on inquiry card.

PHOTO-MANOMETERS. 8-page Catalog 2900 describes multiple-tube well-type manometers with translucent scales and built-in backlighting, designed to be photographed.—King Engineering Corp., Box 665, Ann Arbor, Mich.

Circle 437 on inquiry card.

LOAD, WEIGHT, etc. Three new brochures: 4-page Bulletin M-8 on Lift Truck Weight Indicator available in twelve models, 2,000 to 50,000 lb. capacities; 8-page Bulletin M-15 on entire line of industrial weighing, load measurement and recording instruments, including tension and compression load cell systems, crane weight indicators, dynamometers and tensiometers; 4-page Bulletin M-25 on Sensater Hydraulic Crane Scale available in six capacities from 1,000 to 20,000 lbs.—Martin-Decker Corp., 3431 Cherry Ave., Long Beach 7, Calif.

Circle 438 on inquiry card.

DIAL SCALES. 8-page Catalog 666-B shows many different types of dial scales for a wide cross-section of industry and agriculture, together with related accessories.—The Howe Scale Co., Rutland, Vt.

Circle 439 on inquiry card.

BALANCES. 4-page brochure describes Ultra-Rapid, Rapid, Standard and Semi-Micro models of German-made Sartorius Selecta speed balances.—2-page Bulletin A6288 describes Sauter Ultra-Matic Precision Balance for rapid and repetitive weighing, available in general-purpose and special models for various industries.—Boder Scientific Co., 810-814 Penn Ave., Pittsburgh 22, Pa.

Circle **440** on inquiry card.

DUAL-PURPOSE HOPPER for weighing or storage of fluffy, difficult-to-handle dry materials is described in 2-page Product Data Sheet 5704.—Richardson Scale Co., Van Houton Ave., Clifton, N. J.

Circle **441** on inquiry card.

DYNAMIC MEASURING INSTRUMENTS. 32-page catalog describes more than 40 accelerometers, high-temperature strain gages and associated electronic equipment; presents a series of engineering drawings, tables and graphs giving specs and performance characteristics.—Columbia Research Labs., MacDade Blvd. & Bullens Lane, Woodlyn, Penna.

Circle **442** on inquiry card.

TIME, SPEED

TIME-INTEGRAL MEASUREMENTS. 4-page brochure describes Model 270 Integrating System, an all-electronic instrument for obtaining "the area under the curve" of rapidly-varying, short-term or long-term analog signals.—Allegany Instrument Co., Inc., 1091 Wills Mt., Cumberland, Md.

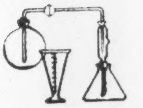
Circle **443** on inquiry card.

TACHOMETERS. 4-page Bulletin No. 795 describes 4"-dial Model "J" stationary tachometers for permanent mounting on machines.—Herman H. Sticht Co., Inc., 27 Park Place, New York 7, N. Y.

Circle **444** on inquiry card.

AIR VELOCITY CALCULATOR is welcome working tool for air conditioning, heating and ventilating; measures 3"x8".—F. W. Dwyer Mfg. Co., Dept. IAN, P. O. Box 373, Michigan City, Ind.

Circle **445** on inquiry card.



ANALYTICAL, LABORATORY

PROCESS CHROMATOGRAPH. 10-page Bulletin CEC 1836 describes new Type 26-202 for remote control and recording.—Consolidated Electrodynamics Corp., 300 N. Sierra Madre Villa, Pasadena, Calif.

Circle **446** on inquiry card.

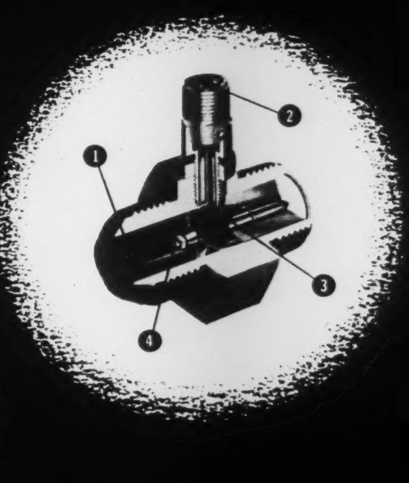
REDOX. 4-page Catalog 17B100 describes O-R-P Cell and Pontentiometer-Type Recorder for measuring, indicating and recording oxidation-reduction potential.—Fischer & Porter Co., 546 Jacksonville Rd., Hatboro, Penna.

Circle **447** on inquiry card.

Waugh TURBINE FLOWMETERS
ARE ENGINEERED FOR ACCURACY AND DEPENDABILITY

① LOW PRESSURE DROP
Helical rotor blades, advanced hydrodynamic design, allow minimum pressure loss in meter.

② HIGH FREQUENCY OUTPUT
Each blade tip generates one electrical output cycle, providing a high frequency signal for improved resolution with electronic counters or for transient flow measurements.



③ RAPID TRANSIENT RESPONSE
Light weight low inertia rotor responds instantly to changes in flow rate, permitting accurate measurement of flow pulsations up to 50 per second.

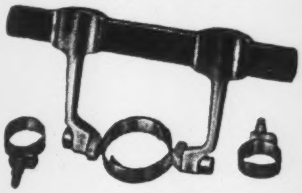
④ EASY DISASSEMBLY
Rotor may be removed and reassembled quickly without effect on flowmeter calibration factor. Rugged construction permits intermittent use at double the normal rate of flow.

Write for Bulletin 101 for complete data.
Waugh ENGINEERING CO. 7842 Burnet Ave., Van Nuys, Calif.

For more information circle **116** on inquiry card.

THE ROLYN
(Snake) Plier

An indispensable tool for assembly and dismantling of optical, radio, scientific instruments and all kinds of mechanical equipment.



The SNAKE PLIER consists of two coil springs with their turns interleaved, attached to two arms projecting from and sliding for adjustment of diameter on the main supporting bar. Two sets of springs are supplied and additional sizes are available.

Ideal for use in all fields where a positive friction grip is required in loosening, or tightening, of the most delicate and fragile threads, or thin wall tubing without danger of damaging, or of marking. Can be used on right or left hand threads. It is equally effective at any angle.

Exhaustive tests in Government workshops and research depts. have proved the efficiency of the Rolyn SNAKE PLIER.

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PLASTIC LENSES FOR AUTOMATION

. . . because they are **UNBREAKABLE,** lightweight, **VERSATILE, LOW COST** and easily machinable

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OPTICS lenses, precision-processed or molded, are ideal aids to instrumentation for purposes of magnification, reduction, image displacement, and a host of adaptations.

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For more information circle **118** on inquiry card.

NEW LITERATURE

MAXIMUM PRODUCT RECOVERY in the Natural Gasoline Plant is discussed in Data Sheet GC-4203 which gives detailed information on use of gas chromatography for optimal output.—Beckman/Process Instruments Div., 2500 Fullerton Rd., Fullerton, Calif.

Circle **448** on inquiry card.

pH INSTRUMENTS. 8-page Bulletin 5400 gives detailed descriptions and specs for all Beckman industrial pH instruments, electrodes and accessories.—Beckman/Process Instruments Div., 2500 Fullerton Rd., Fullerton, Calif.

Circle **449** on inquiry card.

SPECTROPHOTOMETER accessories. 6-page Bulletin 725 covers sampling equipment and other accessories for IR-4 Infrared Spectrophotometer: large-volume and micro sampling cells for liquids, gases, and solids; prism interchange units; recording accessories; etc.—Beckman/Scientific Instruments Div., 2500 Fullerton Rd., Fullerton, Calif.

Circle **450** on inquiry card.

X-RAY MICROSCOPE. 6-page folder titled "A High-Resolution PMR X-ray Microscope with Electron Microscope Conversion" describes the first commercial X-ray microscope that determines chemical composition of specimen.—Instruments Div., Philips Electronics, Inc., 750 S. Fulton Ave., Mt. Vernon, N. Y.

Circle **451** on inquiry card.

FURNACES, OVENS AND BATHS. 4-page Bulletin 5720 introduces several new products including lab-size utility ovens; 800°F mechanical convection ovens; miniature industrial and lab batch ovens; lab-size furnaces (2800°F); muffle furnaces; constant-temperature refrigerated water baths, and new refrigerated visibility jar baths.—Blue M Electric Co., Blue Island, Ill.

Circle **452** on inquiry card.

NUCLEONICS

NUCLEAR FUEL. 5-page bulletin describes melting, fabricating, testing, and quality-control facilities in company's new nuclear and specialty metals plant for manufacture of atomic fuel elements and components, and for fabricating and cladding rare and refractory metal parts.—D. E. Makepeace Co., Pine and Dunham Sts., Attleboro, Mass.

Circle **453** on inquiry card.

NUCLEAR INSTRUMENTS and accessories are listed in new 4-page List 58.—Nucleonic Corp. of America, 196 Degraw St., Brooklyn 31, N. Y.

Circle **454** on inquiry card.

MONITORING SYSTEM for remote areas continually reporting dose rates is described in new 4-page Form 3045A.—The Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, Ohio.

Circle **455** on inquiry card.

NUCLEAR FACILITIES. Five 4-page editions of "Nuclear News" (Vol. 1, No. 1 through No. 5) describe facilities and projects of Nucledyne Corp., subsidiary of company.—Cook Electric Co., 2700 N. Southport Ave., Chicago 14, Ill.

Circle **456** on inquiry card.

NUCLEAR RADIATION TESTING. Environmental testing is described in new 4-page "Newsletter" (Issue 2-556).—Inland Testing Laboratories, 1457 Diversey Parkway, Chicago 14, Ill.

Circle **457** on inquiry card.

RADIO-CHROMATOGRAM scanning system. 4-page Issue No. 14 of "the Nucleus" gives full details of the Actigraph II and its components.—Nuclear-Chicago Corp., 223 West Erie St., Chicago 10, Ill.

Circle **458** on inquiry card.

OPTICAL

CINE THEODOLITE. 8-page brochure describes Kth 57 cine theodolite for ballistic and missile photography produced by P-E's West German subsidiary, Bodenseewerk Perkin-Elmer & Co., G.m.b.H. It is available with three interchangeable lenses, uses standard 35mm film and permits maximum frame rates of five exposures per second.—Perkin-Elmer Corp., Main Ave., Norwalk, Conn.

Circle **459** on inquiry card.

ULTRASPEED CAMERA. 2-page bulletin describes Model UC-1 with Kerr cell permitting one million frames per second, resolution better than 0.001", and 700 successive pictures per test.—Dynamic Measurements Corp., P.O. Box 4067, Pasadena, Calif.

Circle **460** on inquiry card.

LENSES. 6-page folder covers entire line of normal, telephoto and wide-angle lenses made by Pierre Angenieux Optical Works of Paris, France, all of them designed with objective of improving miniature photography.—Exakta Camera Co., 705 Bronx River Rd., Bronxville, N. Y.

Circle **461** on inquiry card.

DATA HANDLING

DATA DISPLAY indicator. 12-page Technical Catalog 1015 describes construction, operation, specification and typical applications of versatile plug-in indicators for data display, storage and transfer.—Union Switch & Signal Div., Westinghouse Air Brake Co., Pittsburgh 18, Pa.

Circle **462** on inquiry card.

RADIO TELEMETERING. 40-page spiral-bound book, titled "A new Company," describes facilities, personnel and eight new systems and components for FM/FM radio telemetering.—Data-Control Systems Inc., 39 Rose St., Danbury, Conn.

Circle **463** on inquiry card.

HARDNESS TESTING

SCLEROSCOPE
FOR TESTING
THE HARDNESS
OF METALS.
PIONEER AMERICAN HARDNESS
STANDARD.
OVER 40,000
IN USE.

DUROMETER
FOR TESTING
THE HARDNESS
OF RUBBER &
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MATERIALS
(ASTM D676)
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90-35 VAN WYCK EXP.
JAMAICA 35, N. Y.

For more information circle 119 on inquiry card.

MACHINE-DIVIDED SCALES

Made with latest
SIP Swiss Automatic Dividing Machines

LINEAR
Accuracy to ±5 microns (0.0002")
Any scale pattern—Any line width
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Accuracy to ±5 seconds

FINE MACHINE ENGRAVING
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Made to any specified pattern
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PROMPT DELIVERY
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PUNCH CARD READER. 2-page Product Data Sheet 5705 describes new PCR Control for automatic control of blending, batching and proportioning operations; outlines unit's use with IBM (or other) punched cards.—Richardson Scale Co., Van Houton Ave., Clifton, N. J.

Circle **464** on inquiry card.

DIGITAL DATA SYSTEMS. Four new brochures: (1) 6 pages, outlines company's capabilities and specialization; (2) 8 pages, describes Model 201 High Speed Digital Plotter; (3) 8 pages, is on Visual Recorder; (4) 4 pages, deals with High Speed Digital Display and Editing Systems.—Tally Register Corp., 5300-14th Ave., N. W., Seattle 7, Wash.

Circle **465** on inquiry card.

ANALOG COMPUTER. 8-page Data File 310 describes new Model 3100 complete console computer for single or multiple operation, featuring 0.1% performance.—Donner Scientific Co., 888 Calinda St., Concord, Calif.

Circle **466** on inquiry card.

DYNAMIC MEASURING equipment and Data Systems are covered in 44-page brochure on company's proprietary products and its capabilities for building systems to original specifications. Included in new products are Q3401 Secondary Pressure Standard, High Speed Commutator.—Wiancko Engineering Co., 255 No. Halstead Ave., Pasadena, Calif.

Circle **467** on inquiry card.

RECORDERS

X-Y RECORDER. 2-page bulletin describes Model 3S Autograph which is a standard X-Y recorder with added feature of a built-in time-base or sweep circuit.—F. L. Moseley Co., 409 N. Fair Oaks Ave., Pasadena, Calif.

Circle **468** on inquiry card.

SHIPPING SHOCK RECORDER. New announcement describes new Model SR-1 which is attached inside shipping case as a tell-tale of shock loads in transportation by air, rail, sea or road, or in factory.—Dynamic Measurements Corp., P.O. Box 4067, Pasadena, Calif.

Circle **469** on inquiry card.

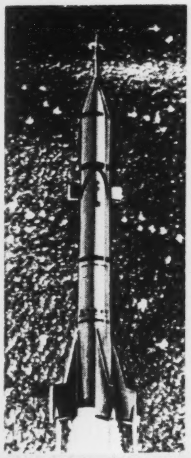
RECORDING POTENTIOMETER. 2-page data sheet describes new dual-pen 5" strip-chart recorder incorporating transistor amplifiers and available with many optional features.—Westronics Inc., 3605 McCart, Fort Worth, Texas

Circle **470** on inquiry card.

TESTING, GAGING

TOOLMAKERS' CALIPER. 2-page announcement describes new Lustro-Chrome stainless-steel caliper with micrometer adjustment.—George Scherr Co., Inc., 200 Lafayette St., New York 12, N. Y.

Circle **471** on inquiry card.



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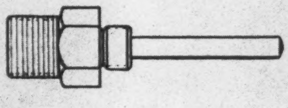
ARNOUX
LOX TEMPERATURE PROBES

Semiconductor Series 7XXXL provide output in *volts** for a temperature span of only 20 F in the liquid oxygen (LOX) temperature range...also can be used with liquid nitrogen, liquid argon, and almost any liquified gas from −240 F to −320 F range.

Applications include temperature-stratification measurements (temperature gradients through a LOX tank), sensing liquid levels in tanks, and pipeline measurements during LOX-fueling operations.

*From 0 to 5 vdc, used with Arnoux TME System or similar equipment.



SPECIFICATIONS

Temperature range: **−240 F to −320 F**
Maximum current rating: **3.0 ma**
Nominal resistance: **12,000 ohms at +77 F**
Calibration accuracy: **0.1 F**
Repeatability and hysteresis: **within calibration accuracy**
Calibration points: **−240 F and −320 F; 1 F increments available between −275 F and −302 F**

ARNOUX foremost in TEMPERATURE MEASUREMENT EQUIPMENT... TRANSDUCERS, ACCESSORIES AND CUSTOM ENGINEERED SYSTEMS

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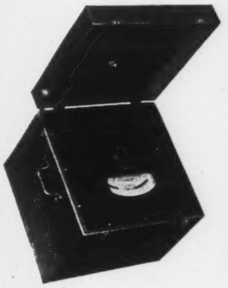
RAWSON
ELECTROSTATIC
VOLTMETERS

Type 518



Available ranges 100 volts to 35,000 volts

Measure true R.M.S. values on A.C., no waveform or frequency errors.

NO POWER CONSUMPTION

Leakage resistance greater than one million megohms. These meters may be used to measure **STATIC ELECTRICITY!**

Ideal for measuring high voltage power supplies with zero current drain. Rugged, well-damped movement. All elements surrounded by metal shielding for accuracy and safety.

Write for bulletin.

RAWSON ELECTRICAL INSTRUMENT COMPANY
"Fine Instruments Since 1918"
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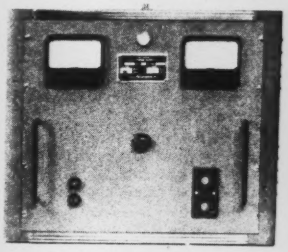
For more information circle **122** on inquiry card.

GATES ELECTRONIC
Announces a
NEW LOW PRICED
REGULATED SILICON
DC POWER SUPPLY



Features:

- Magnetic Amplifier Control
- Ferro-magnetic overload protection circuit
- Eliminates one-time fusing
- Input 115 volts, Single phase 60 cycles AC
- Output 5-30 volts, 40 amperes DC
- Regulation ½%, ripple 1%

Send to Dept. IA for complete information.

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Let us quote on your other POWER SUPPLY REQUIREMENTS

GATES ELECTRONIC CO.
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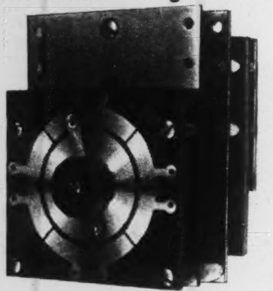

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BALLOON
CONTROL INSTRUMENTS
require MAXIMUM Performance
MINIMUM Size - Weight - Power Drain

Brailsford AGC Timers Are Unmatched In These Basic Requirements

If You Have A Timing Problem Where Size, Mass and Power Drain Are Critical Read These

Model AGC

SPECIFICATIONS
Number of decks—1-4 • Speed regulation—±1.0% at 50% voltage shift
Size—1¾" x 2¼"—depth depends on number of decks
Segments per deck—2-8 for stock units.
Special commutators to order for a nominal tool charge.
Shorting or non-shorting contact • Power input—.008 Amp. at 6 VDC

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ENGINEERING DEVELOPMENT BRAILSFORD MANUFACTURING
SUB FRACTIONAL WATT D.C. MOTORS SIGNALLING SYSTEM COMPONENT

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by C. H. Beard. New "one-book" referance on control valves . . . covers flow characteristics; mechanical features; valve capacity; sizing; body types; positioners; actuators, including d-c, electrohydraulic and gas hydraulic actuators. Numerous tables and illustrations. Paperbound, 236 pages, 1957. ....price $2.00

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by Allan Lytel. A valuable working tool; includes alternative and recommended practice for each step in design and production of printed circuits; a buyer's guie to special components; and "how to" service data. Paperbound, illustrated, 192 pages, 1957. .... $2.00

Electronic Circuitry for Instruments and Equipment

by M. H. Aronson. "Comprehensive source book on instrument circuitry," this complete home -study text includes 458 multiple-choice questions (and answers), 215 illustrations, 10 tables, comprehensive index. Paperbound, 324 pages, 1957 (revised edition). .... price $2.00

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NEW LITERATURE

ENVIRONMENTAL TESTING. 2-page bulletin describes Series H humidity chamber which controls to better than 2°F between 0°F and 200°F and has full automatic programming.—4-page catalog covers temperature, humidity, altitude, sand & dust, fungus, rain & sunshine, and explosion test chambers.—Environmental Equipment Corp., 369 Linden St., Brooklyn 27, N. Y.

Circle **472** on inquiry card.

MASS MOMENT OF INERTIA. 4-page Technical Bulletin No. 20 provides (1) tabulated I_M data on maker's precision pots and (2) description of an experimental method for compiling I_M of other related components within a system.—Technology Instrument Corp. of Calif., 7229 Atoll Ave., N. Hollywood, Calif.

Circle **473** on inquiry card.

GAGES. Adjustable Depth and Groove Location Gage, designed to locate a groove and also measure width of groove in one setting is described in new leaflet.—2-page folder describes new precision Groove Gage for "O" ring grooves, and snap ring grooves and bores.—Mueller Lab., 1052 No. Allen Ave., Pasadena, Calif.

Circle **474** on inquiry card.

WEATHERING AND LIGHT-FADING TESTERS. 2-page bulletin describes Xenotest WPL 394 for accelerating weathering effects of natural sunlight, humidity, rain and temperature; and Xenotest PL393 research, testing, and production control device for accelerating natural sunlight effects on all materials, coated and otherwise.—G. F. Bush Assocs., Box 175, Princeton, N. J.

Circle **475** on inquiry card.

OPTICAL PROJECTORS. 16-page booklet describes features of the various Kodak Contour Projectors and details applications for optical gaging in toolroom, on production line, in receiving, and in final inspection.—Apparatus and Optical Div., Eastman Kodak Co., Rochester 4, N. Y.

Circle **476** on inquiry card.

ANECHOIC CHAMBERS. 8-page folder describes Eccosorb microwave free-space anechoic chambers readily assembled from prefabricated panels selected by user from several immediately-available types of absorbers.—Emerson & Cuming, Inc., 869 Washington St., Canton, Mass.

Circle **477** on inquiry card.

SOIL TESTING. 8-page Volume 2, No. 1 of "The Testing World" features survey on growth of soil testing and soil mechanics; and a story about testing equipment in use at the South Pole.—Soiltest Inc., 4711 W. North Ave., Chicago 39, Ill.

Circle **478** on inquiry card.

TUBING, FITTINGS

SEAMLESS TUBING. 20-page book, titled "Metals for Precision and Performance," contains twenty-two articles and application descriptions.—J. Bishop & Co., Platinum Works, Malvern, Penna.

Circle **479** on inquiry card.

HOSE FITTINGS. 4-page Bulletin RFI describes "Seal-Lock" reusable fittings for high-temperature Teflon hose or Fluoroflex-T Hose. Fittings are field-attachable; triple locking feature locks them to hose and components are locked to each other; cannot loosen from vibration.—Resistoflex Corp., Roseland, N. J.

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SUPER-ALLOY TUBING. 8-page Bulletin 70 describes small-diameter superalloy tubing for applications requiring strength at high temperatures; will not rupture under a stress load of 25,000 psi at 1200° F during a 1000-hour test period and resist oxidation and other types of corrosion.—Superior Tube Co., 1564 Germantown Ave., Norristown, Penna.

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ELECTRICAL, ELECTRONIC INSTRUMENTS

OSCILLOSCOPE. 4-page bulletin describes Type 401, said to be "the most advanced low-frequency scope ever made."—Allen B. Du Mont Labs., Inc., 760 Bloomfield Ave., Clifton, N. J.

Circle **482** on inquiry card.

THE MODULAR CONCEPT is the title of 4-page technical bulletin which explains the principles, the steps, and the requirements, with emphasis on reliability.—Cannon Electric Co., 3209 Humboldt St., Los Angeles 31, Calif.

Circle **483** on inquiry card.

ELECTRICAL CONTROLS. 88-page General Purpose Control Catalog GEC-1260C includes complete product descriptions of motor starters, contactors, relays, solenoids, limit switches, pushbuttons and pilot devices; also contains prices, features, wiring diagrams, dimensions and application information for each device; is indexed for easy reference.—General Electric, Schenectady 5, N. Y.

Circle **484** on inquiry card.

PEAK VOLTAGE measurements. 4-page Vol. 24 No. 11 issue of "Electrical Measurements" discusses basic principles, then describes Model CRV Crest Voltmeter.—Sensitive Research Instrument Corp., 310 Main St., New Rochelle, N. Y.

Circle **485** on inquiry card.

PROGRAM UNIT for Insulation Testers. 2-page bulletin explains why manual operation often causes damage, and how new Model 1102 automatically provides correct sequences and correct rates of increased voltages.—Jackson Electronic & Mfg. Co., Akron 6, Ohio

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ANTENNA PATTERN MEASUREMENTS. 2-page bulletin technically describes Series 402 Wide Range Receiving Systems featuring maximal sensitivity and linearity.—Scientific-Atlanta, Inc., 2162 Piedmont Rd., N.E., Atlanta 9, Ga.

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INDICATING INSTRUMENTS. Two 2-page bulletins: No. 100 describes 250° and 300° scale instruments; No. 101 describes expanded-scale instruments; both available in various sizes.—Miller Instrument Co., Inc., 165 E. Lincoln St., Escondido, Calif.

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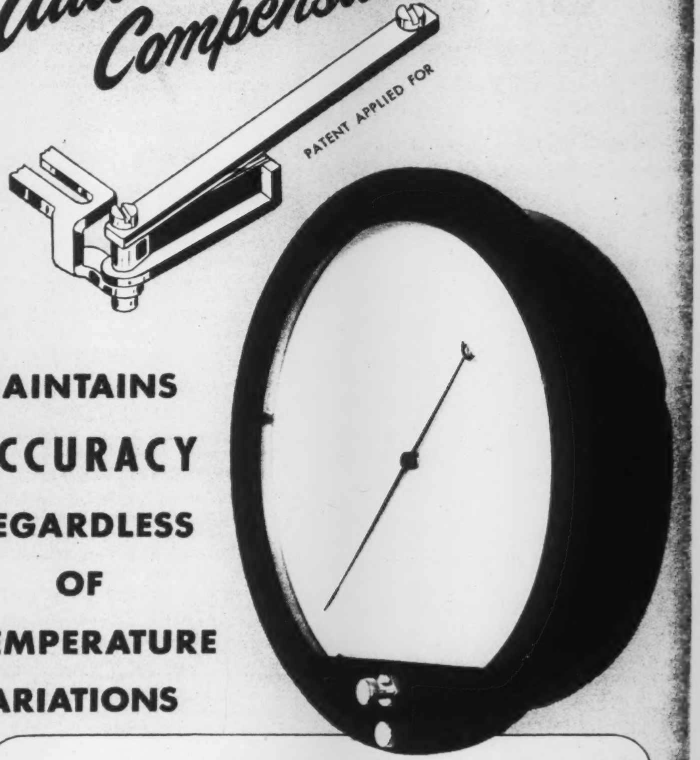

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NEW LITERATURE

RELAYS, SWITCHES

RELAYS. Type F, especially designed for 0.1" grid printed circuits, completely hermetically sealed, are described in new 4-page Sales Engineering Bulletin 124.—C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Ill.

Circle **489** on inquiry card.

SWITCHES. Data Sheet 121 describes a new environment-proof momentary-action toggle switch which can be converted to a maintained contact switch by means of built-in solenoid. —8-page Data Sheet 143 describes modular-mount Series 100 PB lighted pushbutton switches with two built-in indicator lights per unit.—Micro Switch Div., Minneapolis-Honeywell Regulator Co., Spring St., Freeport, Ill.

Circle **490** on inquiry card.

POTENTIOMETERS

10-TURN PRECISION POT. 4-page Data Sheet 1273 (superseding 54-14) describes Series 7600 10-turn 1-13/16" diameter pot, includes a table of coil characteristics, etc.—Beckman/Helipot Corp., Newport Beach, Calif.

Circle **491** on inquiry card.

TRIMMING POTS. 2-page Form No. C.8 describes trimming potentiometers and variable resistors featuring hollow mandrel with wire-wound coil on outside and brush on inside, whence more wire for better resolution and heat dissipation.—Con-Elco, P. O. Box 565, 1711 S. Mountain Ave., Monrovia, Calif.

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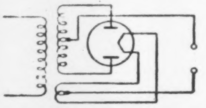

POWER SUPPLIES

TRANSISTOR POWER SUPPLIES. 2-page product data sheet describes three new low-cost T-Nobatron tubeless power supplies for development and/or testing of transistor circuits, relays, computer circuitry, etc.—Sorensen & Co., Inc., Richards Ave., South Norwalk, Conn.

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POWER SUPPLIES. 16-page catalog is said to cover "the widest and most diversified power supply line in the industry . . . more than 900 new power supply models, over half of which have been completely redesigned."—NJE Corp., 345 Carnegie Ave., Kenilworth, N. J.

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TRANSISTORIZED POWER UNITS are covered in 4-page brochure on inverters, converters, and power supplies.—Modern Industries, Inc., 2601 Colorado Ave., Santa Monica, Calif.

Circle **495** on inquiry card.

VOLTAGE SOURCES. 6-page brochure describes DK Series of seven "System-mated" power oscillators featuring ultra-stable voltage, low harmonics, noise and hum.—Electronics International Co., 145 W. Magnolia Blvd., Burbank, Calif.

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DC POWER SUPPLIES. 4-page brochure describes five selenium-rectifier models and five germanium-rectifier models for lab or factory.—Model Rectifier Corp., 557 Rogers Ave., Brooklyn 25, N. Y.

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MAGNETICS

MAGNETICS. Two new 4½-page bulletins describe bobbin cores (Bull.BC-202), and Permalloy powder cores (Bull.PC-103A); and two 32-page catalogs describe tape-wound cores (Cat.TWC-200), and magnetic laminations (Cat.ML-301).—Magnetics, Inc., Butler, Penna.

Circle **498** on inquiry card.

MAGNETIC ALLOYS. 64-page book details engineering properties and fabrication characteristics of special alloys for electronic, magnetic and electrical applications.—Carpenter Steel Co., 3061 W. Bern St., Reading, Penna.

Circle **499** on inquiry card.

ELECTRICAL, ELECTRONIC COMPONENTS

COMPONENTS. 48-page Catalog 581 covers audio Transformers, pulse transformers, filters, discriminators, high-Q reactors, mag amps, ultrasonic components, etc.—Freed Transformer Co., Inc., 1718-1736 Weirfield St., Brooklyn (Ridgewood) 27, N. Y.

Circle **500** on inquiry card.

COMPONENT TIPS for printed-circuit applications are discussed in 2-page announcement which explains time-saving advantages and contains a table of dimensions, etc.—AMP Inc., 21 Paxton St., Harrisburg 30, Penna.

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CORES. 4-page Folder TB-103 illustrates and describes line of consistently-uniform high-quality bobbin cores for use in digital data processing systems; includes data on G-L magnetic materials available: 4-79 Molybdenum Permalloy, and Orthonik.—G-L Electronics, 2921 Admiral Wilson Blvd., Camden 5, N. J.

Circle **502** on inquiry card.

PATCH-BOARD. Section XIII, New Product Bulletin 60 describes new type patch-board intended mainly for test panels and low-cost computers.—Vector Electronic Co., 1100 Flower St., Glendale 1, Calif.

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TERMINALS, BOARDS, etc. (1) 40-page catalog is said to show "the most complete line of terminals in the industry." It includes every popular terminal lug; also covers miscellaneous hardware, tools, etc.; (2) 4-page Price List; (3) wall chart.—Precision Metal Products Co., 41 Elm St., Stoneham 80, Mass.

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BRUSHES. 12-page catalog describes carbon and graphic brushes for all types of rotating electrical machinery.—Speer Carbon Div., Speer Carbon Co., St. Marys, Penna.

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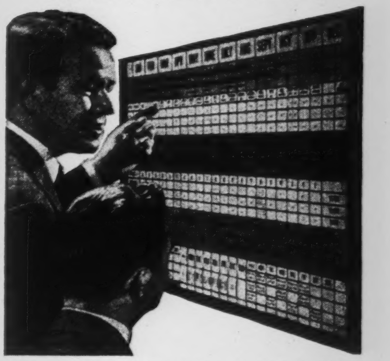

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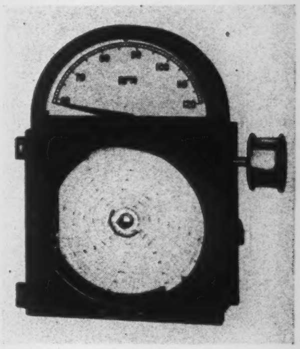

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NEW LITERATURE

CONNECTORS, WIRE

WIRE TERMINATIONS, etc. 20-page "Selestalog" is an annotated directory of company's technical catalogs intended as a reference index.—AMP Inc., 21 Paxton St., Harrisburg 30, Penna.

Circle 506 on inquiry card.

RECEPTACLE. Specification sheet 325 describes Printed Circuit Receptacle CAO 156-6, designed to mate with from one to four printed circuit boards.—Cannon Electric Co., 3209 Humboldt St., Los Angeles 31, Calif.

Circle 507 on inquiry card.

SHEATH CONNECTORS. 16-page catalog covers a complete line of one-piece compression sheath connectors for shielded or coaxial cable.—Omaton Div., Burndy Corp., Norwalk, Conn.

Circle 508 on inquiry card.

CABLES. 2-page bulletin describes watertight cable featuring 3000-psi salt-water immersion and no water penetration even if jacket is damaged.—2-page bulletin announces new cable re-usable after 45 seconds at 2000°F, 15 minutes at 750°F and continuous exposure to 500°F.—Pacific Automation Products, Inc., 1000 Air Way, Glendale 1, Calif.

Circle 509 on inquiry card.

CONNECTORS, etc. 12-page Catalog C 657 covers "pres-SURE-blocks," conduit bushings, staples, splice caps, "Termend" lugs, vinyl splice insulators, etc.—Buchanan Electrical Products Corp., 225 Route 22, Hillside, N. J.

Circle 510 on inquiry card.

WIRE MARKERS. 8-page Bulletin 130-D (superseding 130-C) is a condensed catalog of the many types of self-sticking Perma-Code wire markers, also write-on labels, etc.—W. H. Brady Co., 727 W. Glendale Ave., Milwaukee 9, Wis.

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NICKEL-CLAD COPPER WIRE. 2-page technical information bulletin on Kulgrid 28 Wire, is a guidepost in designing equipment and products which must operate at temperatures up to 1000°F; also presents information on physical properties, etc.—Sylvania Electric Products Inc., 12 Second Ave., Warren, Penna.

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EXTENSION AND ADAPTER SLEEVES for cable-and-connector components are described in 4-page bulletin which contains a table of data on the various types.—Pacific Automation Products, Inc., 1000 Air Way, Glendale 1, Calif.

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COAXIAL CONNECTORS. 4-page bulletin and 1-page spec table cover new types of microminiature components featuring quick lock, quick disconnect and shock resistance.—Electro-Physics Laboratories, 2065 Huntington Drive, San Marino, Calif.

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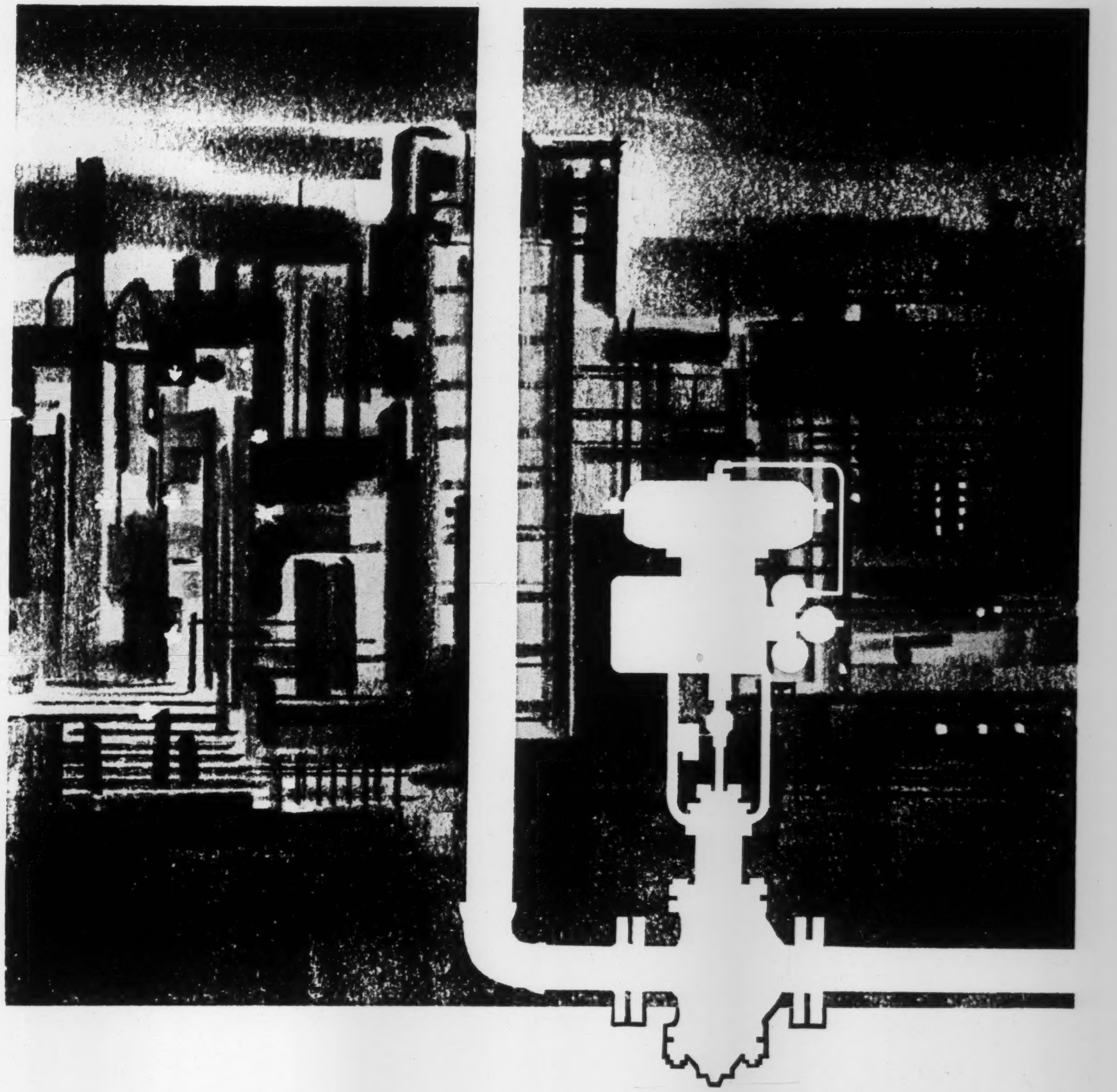

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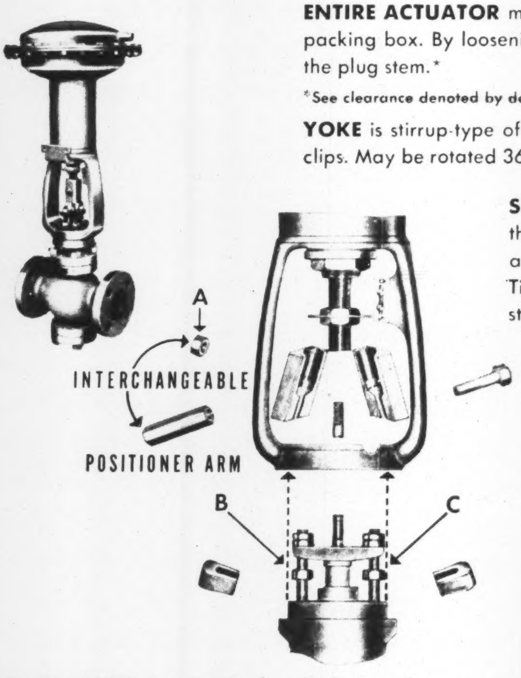

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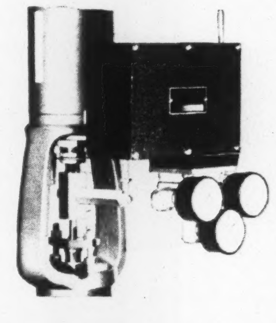

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